Environmental Accounting of Land and Water Resources in Tamilnadu

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Final Report submitted

By

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Table of Contents

List of Figures

List of Tables

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Chapter 1: Introduction and Project Objectives

1.1. Introduction

The measures like Gross domestic Product (GDP) and Net Domestic Product (NDP) have been key indicators in the economic policy making since last 50 years. These measures are part of the national income accounts developed in each country, whose objective is to provide a database for macroeconomic analysis. Besides this, these indicators were for a long time used as a measure of the economic progress of a country and also as a measure of standard of living. These traditional measures of economic activity such as GDP and NDP are now recognised as inadequate as they cannot accurately measure the contribution of environment and the impact of economic activities on environment. As we all know, the environment provides a source of raw materials and energy, serves as assimilator of wastes of production and consumption, provides the context in which all human actions take place and sustains basic life-support systems. However, these traditional measures of economic activity failed to recognise the fact that economy cannot operate in a black box. As a result the national accounts allow depreciation allowance for man-made assets, while the contribution of environmental assets to economy is not valued and hence no depreciation allowance is made for these assets. Thus the depletion and degradation of environment is treated as increases in income, while this depletion and degradation can in fact have negative consequences to the economy in the future. In this chapter a brief review of the national accounts, their flaws and how better indicators of human well being can be constructed are reviewed followed by the objective of this study.

1.2. The Standard National Accounts

The systems of national accounts (SNA) view the relationship between the environment and the economy from economic perspective only (System of National Accounts, United Nations, 1968). The national income accounts are grouped under three categories: current accounts, accumulation accounts and balance sheets. Current accounts deal with production, income and use of income, accumulation accounts cover changes in assets and liabilities and changes in net worth; Balance sheets present stock of assets and liabilities and net worth. The most familiar of the three accounts are the current accounts (the supply and use accounts). The supply and use accounts compute income in three ways: 1) the sum of value added (revenue minus intermediate consumption) across all industries (i.e., the production account); 2) the sum of final consumption and savings (disposable income) (i.e., the use of income account), and 3) the sum of employee compensation and operating surplus (i.e., the distribution of income account). Production in SNA mainly covers only those goods and services that are bought and sold in markets (there are few exceptions).

The supply and use accounts reflect three basic national accounts identities:

1) The supply-use identity

Production + imports = intermediate consumption + exports + final consumption + gross capital formation; (1)

2) The value - added identity

Net Value added = output − intermediate consumption − consumption of fixed capital; (2)

3) The domestic product identity

Gross domestic product = final consumption + gross capital formation + (export - imports) (3)

In addition to the supply and use accounts, there are also asset accounts. The 1993 SNA includes natural assets in the asset accounts only if ownership rights exist and natural assets bestow economic benefits to their owners. Some examples of produced natural assets include the value of livestock for breeding, orchards, private plantations, timber tracts etc. The products of economic assets are generally valued in the market, either directly or indirectly. These assets are referred to in the SNA as economic assets. The asset balances for produced assets and non-produced natural assets include the opening and closing stocks of produced assets and the elements explaining the change between the two i.e., net capital formation, holding gains or losses of assets, other changes in volume of produced assets and the closing stocks (i.e., opening stocks plus the sum of the preceding adjustments). Due to inclusion of asset accounts also in the national accounts we have one more set of identity, which explains the difference between opening and closing stock of assets by flows during the accounting period.

For produced and non-produced assets, the balances are identified as:

Closing stocks = opening stock + gross capital formation − consumption of fixed capital + other changes in volume of assets + holding gains/losses on assets (4)

The gross capital formation consists of a) gross fixed capital formation and b) changes in inventories in produced assets like building roads, machinery, stocks of commodities etc. The gross fixed capital formation may also include additions to the produced assets such as improvement of land, cost of transferring land and other non-produced assets between owners. The value of capital formation is added to the value of non-produced assets, but separately 'depreciated' as other changes in volume. Thus, the elements of the column related to non-produced economic assets, do not figure in the calculation of NDP, as all the changes in non-produced natural assets between opening and closing stocks are explained in the SNA as holding gains or losses and other changes in volume of assets.

Hence, the elements under other changes in volume are the most relevant items to be reclassified for analysis in the natural resources accounting.

1.3. Flaws in the Conventional System of Accounting

The main flaws in the conventional national accounts discussed earlier can be listed below:

1) The traditional measures focussed mainly on goods and services that are bought and sold in markets and ignored the non-marketed services provided by natural assets. For example, forests provide many environmental services like flood control, protection from soil erosion, carbon sequestration and amenity values in addition to marketed products like timber and fuelwood. The national accounts only consider the economic contribution of forests and ignore the environmental services. Similarly, the waste disposal services of the environment are not recorded in the national accounts.
2) There is inconsistent treatment of man-made and natural assets. As mentioned earlier, while computing sustainable income measures like net national product or net domestic product, the man made machinery is depreciated so as to allow for replacement of losses in the capital stock. However, losses in the natural resources are not similarly depreciated. For example, when forests are transferred for non-forest purposes, the national accounts record only the expenditure incurred in clear-felling the forests, and do not account for the loss to society as a result of this transfer. Moreover, the reduction in the forest area is shown in other volume changes, which do not have any affect on GDP.
3) These measures like GDP and NDP do not adequately represent the degradation of environment. Some times the expenditures incurred in restoring the environmental quality are accounted as increases in national income and product. For example, cleaning up of rivers, treating water for drinking, preventive expenditures to protect from ill effects of pollution all are shown as increases in GDP.

Thus, this traditional system of accounting implies that the environmental assets like air, water etc. may be degraded due to economic activity, resulting in a reduction in social welfare; however corresponding adjustment need not be made in the accounts. This gives a false impression of increase in income while natural wealth is reducing. Further, ignoring the contribution of non-market value of environmental goods and natural resource depletion will result in misrepresenting the current well-being and distorts the economy’s production and substitution possibilities. Thus the current measures of national income are inadequate as indicators of social welfare, and moreover provide misleading information about whether an economy is using its resources sustainably. Thus the policy-makers are not rightly informed on the important link between economic growth and the environment. Hence environmental accounting can be useful in removing the current biases.

1.4. How can we modify these measures to measure the income accurately[1]?

Although there has been wide consensus that greening the national accounts is important, there has been no consensus on how to do it. Different researchers have advocated different approaches. Some are concerned with preserving the stock of environmental assets; and others with the effect of environmental change on welfare. The various approaches can be grouped under four headings. These are: 1) Pollution expenditure accounting; 2) Physical accounting; 3) Development of green indicators 4) Extension of the SNA type system and developing wealth indicators.

1.4.1 Pollution Expenditure Accounting

This has been the earliest reaction to overcome the weaknesses in the conventional economic accounts. This involved developing data series on pollution abatement and other environmental expenditures. Such data series has been maintained by USA since 1972 and are also available for other OECD countries. However, there are some limitations of using this approach: 1) These data refer to expenditure already incurred, either due to policy or standard business and household practice. Hence they should not be considered as additions to conventional economic accounts as they are a re-specification of the information already accounted for; 2) The abatement expenditure data can tend to overestimate the true opportunity costs, as they contain outlays on materials, which are already included in the value-added expression of the sector producing these materials. Thus there may be the risk of double counting; 3) The practice of comparing pollution abatement expenditures with GDP is misleading since the GDP covers primary costs and is free from double counting. This can be addressed by using input-output techniques. The use of pollution expenditure data has limited scope for policy. They can only give an indication of how various environmental policies may affect the productivity.

1.4.2 Physical Accounting

The second approach to improve the conventional economic accounts is to supplement these accounts with physical information about the natural environment and its status i.e. one can provide information on physical indicators for forests like the area under dense forests, open forests, volume of stock of timber, area disturbed by fire etc; or give the quality of air in terms of CO_2 emissions, suspended particulate matter, nitrogen oxide emissions etc; or water using physical indicators like dissolved oxygen, BOD, COD, pH etc. Such type of information can also be arranged in conventional input-output type of matrices. For example Netherlands has used such a complete input-output matrix

[1] Sections 4.1 to 4.4 are based on Uno and Bartelmus (1998)

system in their National Accounting Matrix including Environmental Accounts (NAMEA). The system fully integrates economic and physical environmental information.

Development of such physical accounts is important as the accounts can provide the inputs for the construction of various environmental indicators and thus be used for scorekeeping purposes[2]. However it is very difficult to use these physical accounts for policy purposes. Some of the reasons include: 1) the choice of appropriate physical units of measure is not obvious; 2) there is incomparability of units 3) difficulty in getting condensed description as the units are not similar; 4) involve development of huge data sets due to different quality indicators for forests, air, land and water without reaching general conclusions on their (economic and non-economic) significance; 5) the potential severity of the environmental problem not reflected and hence the decision-makers will not be able to set relative environmental priorities while taking various investment decisions. This can be illustrated using an example. For example a forest can be measured in terms of its area, volume of timber, number of species of flora and fauna etc. Even the units of measuring forests are different. For instance, area is measured in hectares, volume in cubic metres and the species in number. Thus there can be no common unit, which can be used to indicate all the three. Another choice that has to be made is which physical measure to choose. This once again depends on the policy objective in mind, i.e. should the forests be used for timber management or provision of firewood or preserving biodiversity. This results in developing huge data sets without reaching any conclusion for the policy. For instance, if a policy maker is faced with the dilemma of preserving hundred hectares of forest, which is a rich source of biodiversity versus developing multipurpose project, which provide numerous quantifiable benefits, the latter is favoured against the former, as they cannot get the value of the benefits of preserving the forests.

1.4.3 Green Indicators

A third approach has been to construct a green GDP or some other economic index to replace the conventional GDP or NDP. Two approaches have been adopted for this. In the first approach, efforts were made to construct entirely new indicators of well-being. This has been achieved by altering the conventional aggregates like subtracting out pollution expenditures from the GDP, adding the factors like negative effects of urbanisation etc. Some of the examples of this approach are the Measure of Economic welfare (MEW) indicator by Nordhaus and Tobin, the net national welfare (NNW) indicator developed for Japan (Economic Council, Japan, 1973) and the Index of Sustainable Economic Welfare (ISEW, Daly and Cobb, 1989). The second approach did not involve replacement of conventional gross income aggregates but involved modifying the conventional measures of net

[2] 'Score keeping function' means the function of maintaining a record of performance of the economy.

product. Such an approach has been provided by Repetto and his colleagues at the World Resources Institute (WRI; Repetto *et al.*, 1989). Essentially, their idea is to depreciate natural assets such as forests, mineral stocks, fish stocks and soils in order that reproducible capital and natural capital receive equal treatment in the computation of net income. The main criticism of the approach is that while various indexes may indicate that society is worse off than might be suggested by the conventional GDP, they give the policy maker a little indication of what to do about it.

1.4.4 Extensions of the SNA-type Systems

The fourth group builds upon the existing SNA and covers all the sectors that interact with the environment rather than focussing on just one element of the conventional accounts such as depreciation or pollution expenditure accounting. Examples of such an approach are the United Nations Satellite System of Integrated Environmental and Economic Accounting (SEEA) and Environmental and Natural Resource Accounting Framework (ENRAP) (also referred to as Peskin framework). Both the approaches require sector-specific information on the use of environmental assets, and are concerned with the management and score keeping functions of accounting. But the principal difference between these two lie in the extent of their adherence to SNA concepts. SEEA appears much more concerned with adherence to the principle of SNA than to economic theory. The ENRAP framework, on the other hand, stresses more on the consistency with economic theory than with the SNA (Peskin, 1998, page 387)[3].

The SEEA attempts to overcome the limitations of the SNA by reclassifying the elements in other volume changes so as to include them in the calculation of NDP. In the absence of international consensus on how to incorporate environmental assets and the costs and benefits of their use into national accounts, the United Nations Statistical Division approved the “satellite” System of Integrated Environmental and Economic Accounting framework rather than modifying the core SNA itself (United Nations 1993). The satellite system becomes a link between the SNA and the accounts describing the natural environment. The United Nations Conference on Environment and Development (UNCED) in its Agenda 21 also ratified this approach. The main success of SEEA is because of its close integration with the SNA and also due to its ability to address various flaws of conventional national accounts by means of alternative versions or modules. The building block approach allows SEEA users to choose among different approaches according to their priorities and statistical capabilities.

The main objectives of SEEA are (Bartelmus *et al*., 1994):

[3] For example, if willingness to pay to avoid environmental degradation is the correct way to measure the value of pollution damage, while calculating the cost of pollution controls the incorrect way, the ENRAP framework chooses the former over latter though the latter is easier to measure.

1) ***Segregation and elaboration of all environment-related flows and stocks of traditional accounts***

The objective of this module is to present separately environmental protection expenditures[4]. These expenditures have been considered as part of the costs necessary to compensate for the negative impacts of economic growth, in other words as defensive expenditures.[5]

2) ***Linkage of physical accounts with monetary environmental accounts and balance sheets***

This module consists of a description of the interrelationships between the natural environmental and economy in physical terms (like changes in total stock or reserves of natural resources and changes therein, even if those resources are not affected by the economic system). These accounts provide the physical counterpart of the monetary stock and flow accounts of the SEEA.

3) ***Assessment of environmental costs and benefits***

The SEEA expands and complements the SNA with regards to assigning costs to a) the use of natural resources in production and final demand; and b) the changes in environmental quality, resulting from pollution and other impacts of production, consumption and natural events on the one hand, and environmental protection expenditures on the other.

4) ***Accounting for the maintenance of tangible wealth***

The SEEA broadens the concept of capital to cover not only the man-made but also the natural capital. Natural capital includes scarce renewable resources such as marine or tropical forests, non-renewable resources like land, soil and subsoil assets (mineral deposits), and cyclical resources of air and water. Capital formation is correspondingly changed into a broader concept of capital accumulation.

5) ***Elaboration and measurement of indicators of Environmentally adjusted product and income***

Including the costs of depletion of natural resources and changes in environmental quality allows the calculation of modified macroeconomic aggregates in SEEA. Indicators thus compiled include, in particular, an environmentally adjusted net domestic product (EDP).

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[4] Environmental protection expenditures are actual expenses incurred by industries, households, the government and non-governmental organizations to avoid environmental degradation or eliminate the effects after degradation has taken place. They are included in the SNA, but are usually not identified separately in the conventional production and final use accounts.

[5] The defensive expenditures are the expenditures incurred to repair the environment or the abatement expenditures incurred to prevent further damage to the environment like installation of electrostatic precipitators to remove SPM in a boiler or a furnace or a de sulphurization process to remove sulphur oxides.

Modules 3, 4 and 5 require valuation of environmental resources. In order to facilitate this, SEEA proposes three different versions based on different techniques of valuation. One version of SEEA applies a market valuation approach. The second version uses a maintenance cost approach and the third version combines the market valuation with the contingent valuation approach. Of all the market valuation is the closest to the conventional SNA. In the market valuation approach, the stocks of non-produced economic and environmental assets can be valued using either the net-price/discounted present value/user-cost methods. The net price of the asset is defined as the actual market price of the raw materials minus its marginal exploitation costs including the rate of return on the invested produced capital. In case of exhaustible resources SEEA proposes using the user-cost method to value the depletion. The idea of this method is to convert a time-bound stream of (net) revenues from the sale of an exhaustible natural resource into a permanent income stream by investing a part of the revenues, that is, the 'user-cost allowance' over the lifetime of the resource. Only the remaining amount of revenues should be considered as 'true income'. The discounted present value of natural resources is obtained by using the discounted value of the goods extracted/services provided by those assets in the future reduced by the exploitation costs (net return). However, the limitation of market value approach is that it covers only those natural assets that have an economic value. As an alternative to market valuation, maintenance cost valuation is introduced. Maintenance costs are defined as the costs of using natural environment that would have been incurred if the environment has been used in such a way that its future use had not been affected. The maintenance costs concept implies that uses of the environment that have no impacts on nature have a zero (monetary) value i.e. if water is available in plenty, extracting water does not have any value.

The other most important improvement in SEEA over the SNA is the extension of the asset boundary. In SEEA the term 'natural resource' is used in a much broader sense than SNA's definition of 'economic non-produced natural assets'. The SEEA identifies separately non-produced economic assets and non-produced environmental assets (instead of non-produced natural asset) in addition to the produced economic assets. 'Produced assets' are those assets that result in future benefits to their owners. In the category of 'produced assets', the natural assets consist of all those whose growth is controlled by man through the process of cultivation, including vineyards, orchards, timber tracts and other plantations, inventories of agricultural crops standing on the land after harvesting etc. 'Non-produced economic assets' are those natural assets that are currently exploitable or likely to be so, for economic purposes, even if no explicit ownership or control is currently exerted over these resources and have market price if they can be exploited. For example, fish in oceans or timber in forests, which can be exploited for commercial purposes, come under this category. 'Non produced environmental assets' are those assets for which neither ownership rights are enforced nor direct monetary benefits are derived from their use. For example, forests provide other environmental services like global climate balance, which are not commercially exploitable. Such type of assets, which provide only environmental services but cannot be commercially exploited come under this type. These assets include air, land and terrestrial ecosystems (excluding forests), forests and forestland in wilderness, rare and endangered species of fauna and flora, water and aquatic ecosystems.

Apart from the extension of the asset boundary in the SEEA, the information on 'other changes in volume' for non-produced economic and environmental assets is disaggregated into four categories (Bartelmus and van Tongeren, 1994: p 7). These categories are:

- Depletion: reductions in the quantity of assets, due to economic uses (e.g., timber harvesting)
- Degradation: positive or negative changes in the quality of assets, due to economic decisions (e.g., soil erosion due to forest loss leading to loss of land productivity)
- Other accumulation: additions or reductions in the quantity of assets due to economic decisions (e.g., additions due to afforestation or reduction due to transfer of forests to non-forest uses like agriculture etc.)
- Other volume changes: quantitative or qualitative changes in assets not caused by economic decisions (e.g., destruction of forests by natural fires etc.)

Like SEEA, the starting point for ENRAP is the conventional national economic accounts. The ENRAP accounting structure is based on the premise that economic accounts should attempt to cover all the economic inputs and outputs that, together, comprise an economic system. For inputs and outputs to be "economic" they need not have market prices. The natural environment is one such example. ENRAP includes the excluded goods and services from the national accounts under three categories: input services (e.g., waste disposal services); output or environmental quality services (e.g., recreation and aesthetic services); negative outputs (e.g. pollution). The basic ENRAP strategy is to append these non-marketed services to the marketed services already accounted for in the conventional accounts. The monetary value of these services is obtained using estimated shadow prices. This treatment is similar to SEEA. The modified accounts are completed with two other entries. The first, non-marketed household production covers the nonmarketed household production like firewood collection. The final entry is natural resource depreciation, included along with conventionally measured capital depreciation. Both entries are included to provide a measure of modified net national product, modified to include the depreciation of natural assets as well as marketed assets.

1.4.4. Wealth indicators

This literature builds on important contributions by Weitzman (1976), Hartwick (1990) and Mäler (1991). The framework in most contributions is "extended Hicksian" as the focus typically is on accounting for the value of changes in total wealth in national income. National income is typically defined along the (optimal) path of a growth model for a simple economy with stocks of goods (including natural assets used in production) and bads (including environmental liabilities that negatively affect utility). A generalised expression for (net) national income aggregate is:

$$NNP = C + \sum p_i \dot{X}_i = C + G \qquad (1)$$

where *NNP* is equivalent to the dollar value of consumption (*C*) plus the sum of net changes in *i* assets ($\dot{X}_i$) each valued at its shadow price (p_i). Alternatively, this can be written as consumption plus adjusted net or genuine saving (*G*). An interpretation of *NNP* is that it measures extended Hicksian income: that is, the maximum amount of produced output that could be consumed at a point in time while leaving wealth (instantaneously) constant (Pemberton and Ulph, 2001). Given an interpretation of sustainability that the change in the (real) value of total wealth should not be negative in the aggregate, this definition of Hicksian income suggests that our focus should be on genuine saving or *G*. The reason for this is that *G* tells us about (net) change in wealth in that it can be shown that (Dasgupta and Mäler, 2000):

$$\dot{W} = 0 \text{ if } G = 0 \qquad (2)$$

That is, the change in the present value of utility ($\dot{W}$) or wealth is zero if genuine saving is zero. More specifically, the key finding in this literature is that a point measure of $G_t<0$ means that a development path is unsustainable (Hamilton and Clemens, 1999).[6] That is, negative genuine saving implies that the level of utility over some interval of time in the future must be less than current utility – development is not sustained, to use Pezzey's (1997) terminology. Moreover, Hamilton and Hartwick (2004) and Hamilton and Withagen (2004) show that positive *G* results in development being sustained so long as the rate of change in *G* is no greater than the interest rate: that is, for example, an outcome which can be achieved by a policy rule of constant (positive) net saving.

Pearce and Atkinson (1993) provided one of the earliest suggestions for a practical indicator – which Hamilton (1994) later termed 'genuine' saving – based on this notion that negative net saving should be avoided. Estimated rates of genuine saving for a broad range of countries are now published annually by the World Bank (e.g. World Bank, 2003). These data make it clear that *persistently*

[6] The finding that negative genuine saving is unsustainable holds for (characterisations of) non-optimal development paths (Dasgupta and Mäler, 2000).

negative genuine saving rates characterise a number of countries at various periods over the past three decades.

An important development is offered by Dasgupta (2001) and Hamilton (2003) in response to the question as to how sustainability should be measured when population is growing. That is, *G* measures only the change in total wealth whereas, in much of the developing world, the reality is that population is growing at relatively rapid rates. This means that total wealth must be shared amongst even more people. In such circumstances, the net change in total wealth per capita is a better measure of sustainability. This can be written as follows (Hamilton, 2003):

$$\frac{d}{dt}\left(\frac{W}{N}\right)=\frac{\dot{W}}{N}-\frac{gW}{N}=\frac{G}{N}-\frac{gW}{N} \qquad (3)$$

where *W* is total wealth, *N* is total population and *g* is the population growth rate. Hence, the net change in total wealth per capita, $d/dt(W/N)$, is equal to change in total wealth (i.e. $\dot{W}$ or *G*) divided by total population (*N*) minus the product of total wealth per capita (*W*/*N*) and the population growth rate (*g*). Ferreira *et al*. (2003) refer to this latter component of the (right-hand side of the) above expression as a 'wealth- dilution' term. Put another way, it represents the sharing of total wealth with the extra people implied by a country's growth in population. Clearly, for a population growth rate that is strongly positive then $d/dt(W/N)$ could provide a very different signal to policy-makers about sustainability prospects than the 'traditional' genuine savings rate. Both indicators, therefore, are important and we make use of both in what follows.

Lastly, it is worth noting that a number of contributions such as Ekins *et al*. (2003) have sought to construct indicators of changes in critical natural capital: that is, where forest services and climate functions are maintained by holding relevant stocks and liabilities at target physical levels.

1.5 Studies on Natural resource accounting In India

Though it is important to account for natural resources in the national accounts, only a few researchers demonstrated how to account for natural resources in the national accounts. A comprehensive study at the state and national level has been done by Haripriya (1998, 2000) and Haripriya (2001). Haripriya (1998, 2000) made an attempt to incorporate the forest resources in the state accounts of Maharashtra using the SEEA framework. In another study Haripriya (2001) incorporated the forest resources into the national accounts for all the states. The study constructs accounts containing information on the opening stocks, changes due to economic activity (due to logging/illegal logging/afforestation), other accumulations (mean annual increment, regeneration and transfer to nonforest purposes), other volume changes (due to forest fires, stand mortality, animal grazing etc.) and the closing stocks. The value of depletion is obtained by deducting the value of opening stocks from the value of the closing stocks. The studies adjusted the NDP in two ways. First, adjustments were made in the forest sector to include non-market production of timber, fuelwood and non-timber forest products left out of NDP. This converts NDP to Adjusted Net Domestic Product (ANDP), Second the study adjusts ANDP for the depletion of forest assets to derive environment adjusted domestic product (EDP). The forest accounts were limited to incorporating monetary benefits from timber, fuelwood, fodder and non-timber forest products. The study done for Maharashtra illustrates that the ratio of Environment adjusted state domestic product to Adjusted Net state domestic product is around 99.3 percent. In yet another study Atkinson and Gundimeda (2004) accounted for the carbon benefits of forests along with other benefits mentioned in the earlier studies. In relation to *GNP*, the findings with regards to the net change in forest wealth in India indicate that this magnitude is significant but possibly no greater than 1%. Gundimeda et al (2005), (2006), (2007) illustrated how to account for timber, fuelwood, carbon, biodiversity, ecotourism values of forest resources for different states and also developed accounts for agriculture.

Some other researchers also tried to account for natural resources but not specifically in the context of SEEA framework. Chopra and Kadekodi (1997) for instance illustrated how to account for forests in Yamuna Basin for four states in north India. They have considered extraction, regeneration, degradation and preservation of forest resources. They considered four parameters: total dense forest area, annual forest degradation rate, extraction rate and regeneration rate. From these physical values monetary value of the parameters are deduced. The shadow price of the stock of forest resource has been estimated using the ecological value of the biomass, which includes timber, ntfp, ecological function values etc. To estimate the value of the degraded area, the study uses contingent valuation method to analyse the WTP by the local communities to protect this forest area. The Preservation value of the forests in the Yamuna Basin is estimated using the net contribution of the tourists per year in Bharatpur National Park. The net contribution of the tourists per year is obtained using the Travel cost method The study found that the adjusted SDP of Himachal Pradesh, on account of excessive extraction over and above regeneration can go down by as much as 21.64%. The estimates of SDP adjustments for other states are –0.73 % for Rajasthan, -2.53% for Uttar Pradesh, and 0.04% for Haryana.

In another study, Murty et al. (1999) illustrated how to account for water pollution. water pollution is measured by a number of indicators like biological oxygen demand (Bod), chemical oxygen demand (COD), pH, Suspended Solids, Dissolved solids, variety of chemicals, metals etc. two approaches have been used in the literature to value and account the impacts of water pollution. The first is to assess the health and other impacts of water pollution on human and animal life. The second is take account of the cost of water treatment before discharging the effluents into the rivers etc., following the principle of “polluter pay”. Brandon and Homman (1995) used the first approach to provide an all-India level estimate of urban and rural health effects due to water pollution (measured basically in terms of mortality and morbidity rates). Taking the estimate of reduction in disability adjusted life years (daly) of the Indian population, they estimated the cost of water pollution in India to be anywhere between us$ 3076 to us $ 8344 billion. However, Murty et al. (1999) provide an alternative estimate based on the principle of ‘polluter pay’ in establishing effluent treatment plans. According to him, the total value added by Effluent Treatment Plant activities are estimated to be Rs.64.10 lakh as against Conventional Gdp of Rs. 5,98,964 Crore in the Indian economy in 1991-2. However, since the estimate is based only on about 25 percent of the industries, the actual value-added lost in conventional GDP are of the order of Rs 16 Crores.

Parikh and Parikh (1997) made an attempt to account for air pollution in India, using input-output sectoral information at the all India level, power and transport sector and household level emissions (including livestock sector). Two approaches can be used to value and account the air quality changes within an income accounting framework. They are: Maintenance cost or Avoidance cost approach. Parikh and Parikh used the second method of assessing the damage due to air pollution. Other than the individual research studies, Central Statistical Organisation has also commissioned around eight studies on natural resource accounting of which this study is a part.

2. Objectives and Scope of the Project

The objectives of the study are to incorporate the natural resources into the State accounts of Tamil Nadu. To be consistent with the existing system of national accounts, we propose to implement the SEEA framework. We propose to develop comprehensive set of accounts for Land and Water for the state of Tamil nadu. The specific objectives of the proposed study are to:

1) Develop physical accounts for land and water;
2) Develop monetary accounts wherever possible;
3) Estimate the cost of degradation of water and land resources to the economy and
4) Account for the interaction between the economy and the environment in the conventional accounts.

The rest of the report is structured as follows. In this chapter a brief introduction about the need for environmental accounting and various approaches to environmental accounting are discussed. In Chapter 2 I discuss the suggested SEEA framework along with the scope of operationalising the framework for the state of Tamil Nadu.

3. Structure of the Report

In the Chapter 2 we discuss the feasibility of constructing physical accounts to incorporate land and water resources for the state of Tamil Nadu. As the data requirement for land and water accounts are very different, we discuss ways to account for various land uses separately. In chapter 3 a framework to account forest resources into the national accounts is developed. In chapter 4 framework to account for agricultural, pasture and wasteland is developed and chapter 5 discusses the framework to incorporate water resources. Chapter 6 concludes with data limitations and the data required.

Chapter 2: Physical Accounts for Land and Water in the National Accounts

2.1 Conceptual Framework

Land is defined as the area within the national territory that provide direct or indirect use benefits through the provision of space for economic and human activities. Though Land is an important natural asset, it is different from other natural resources because it can neither be created nor destroyed by man or neither imported nor exported but can change in quality due to human intervention. However, the degradation of land can have implications for the economic growth. Water resources are defined as “the water found in fresh and brackish surface water and ground water bodies within the national territory”. In the case of surface water, the volume in artificial reservoirs and watercourses is included in addition to that in natural water bodies. The water of the oceans and open seas is excluded because the volume of water is too huge to make any meaningful measurement.

The main differences between treatment of land and water in SNA and SEEA are as follows:

- The 1993 SNA includes only land areas over which ownership has been established and that can be put into economic use. For example recreational land is considered as an asset because it provides some economic benefits. If the land is used both for recreation as well agriculture, whichever category gives higher returns is considered. Similarly only ground water resources are treated as distinct asset to the extent that scarcity leads to the enforcement of ownership and/or use rights, market valuation and some measure of economic control.
- However, in SEEA the economic view of land or water is only part of the picture. SEEA explicitly includes all land on the grounds that it might one day provide use benefits even if it does not today. In SEEA the categories are defined by use. Further as economic use of land is often connected with short or long-term processes of deterioration (or improvement) it is also treated as an environmental asset in SEEA. For example, the opening of uncultivated land (such as forests or wetlands) for recreational or agricultural processes may upset ecological balances, the use of areas for traffic or human settlement can radically change the characteristics of land and ecosystems, agricultural use of land could cause soil erosion etc. On the other hand, the introduction of less intensive management practices (e.g. organic farming) or restoration activities may lead to improvement. Similarly SEEA included all ground water and surface water resources on the basis that they may one day provide some benefits. Surface water is treated as an environmental asset because water can be extracted from the environment and be put to economic use.

Though land and water can be treated as two different assets and require different accounting procedures, in the present work they are treated together. This is because of two reasons. Water can be treated as an ecosystem input, product and residual. Water is an ecosystem input because without water there is no agriculture and automatically the productivity of agriculture would be very low. That means it is implicitly included. Similarly it can be used as a product. If there is market for water (in the form of bottled water or irrigation water), it is already included in the national accounts. Wastewater does not have separate market but the extent of degradation of water quality can be captured. Some industries buy wastewater. In this case it is already recorded in the national accounts. So as water is already implicitly accounted for in household, industry and domestic sector, it is not treated separately. Secondly, for monetary valuation it is important to place a value on water. However, the value is implicit with land. When we buy a house we automatically become the owner of the water resources in our land. The price we pay also includes the stock of water. So it is difficult to treat these two differently.

Hence, we combined land and water under one head as done in SEEA. In SEEA land and surface water assets are sub-divided into five land cover categories: land underlying buildings and structures; agricultural land and associated surface water; wooded land and associated surface water; major water bodies and other land. These five land cover categories can be out to different uses by humans which is referred to as Land use. Land Use is referred to as "Man's activities and the various uses which are carried on land" (NRSA, 1989). Some of the examples for land use include dwellings, industrial use, transport, recreational use or nature protection areas. In other words, Land cover reflects the (bio) physical dimension of the earth's surface and corresponds in some regard to the notion of ecosystems. Land use is based on the functional dimension of land for different human purposes or economic activities. A given surface can be a "forest" from the land cover point of view, but from the land use perspective it may belong to timber production, recreational areas, nature protection areas or to area of no use. Land use in terms of human activities may result in changes in biophysical land cover (e.g., deforestation, building a road, urbanization) or in changes of the conditions of the land cover. In principle land use can be better linked to economic activities. The land cover results from both the use of land by activities and the natural processes, whether modified by human activities or not.

To measure the national income more accurately, two types of adjustments to the existing national income and product accounts are required.

- The first adjustment requires defining and valuing non-marketed environmental goods and services.
- The second adjustment requires measuring and valuing stock changes in natural resources.

For example, to account for natural resources like forests, one should extend traditional NDP by including the non-marketed benefits associated with forests. In addition, the traditional NDP should also be adjusted for the value of change in the forest resources.

For this the following procedure can be adopted depending on the availability of data:

1) Construct physical accounts for the stock of land cover under different categories: i.e land underlying buildings and structures; agricultural land and associated surface water; wooded land and associated surface water; major water bodies and other land at different points of time.
2) Classify the land use under each category, i.e for example the land cover category, land underlying buildings and structures can be categorised by purpose of use.
3) Similarly the land use can be categorised by different sectors or activities if possible for more accurate valuation.
4) Construct the land cover change matrix between two different periods of time
5) Classify these changes into
    - Opening stocks,
    - Changes due to economic activities,
    - Other volume changes
    - Other accumulations

Figure 2.1 gives the structure of the core set of land cover or land use accounts

6) Find the marketed and nonmarketed values of different aspects of land use. For example, forests have several marketed and nonmarketed benefits, which may not have been considered in the national accounts. Similarly water bodies or agricultural land may have some nonmarketed externalities which needs to be accounted for.
7) Construct monetary accounts for different categories of land cover/land use.
8) Estimate the cost of environmental degradation as a result of the changes in land use.
9) Find the net change in asset value by summing across different categories of land use or land cover.
10) As the land cover is fixed but can only change between the categories, the change from one category to another can result in either increase of decrease in value. One has to estimate the total value of net accumulation across all the categories of land cover and deduct or add it to NDP to find the net change in value of the asset and deduct or add it to NDP.
11) Deduct the value of environmental degradation caused due to changes in the assets from the above to obtain the adjusted state domestic product.

Figure 2.1. Structure of the core set of land cover/land use accounts

A. Stocks

Land cover x land use matrix

	Land cover	Σ
Land use		
Σ		

B. Changes

Land cover changes matrix

	Land cover (final state)	Σ
Land cover (initial state)		

Land use x activities matrix

	Land use	Σ
Activities/ Sectors		
Σ		

Land cover changes core account

		Changes (gross/net imputed to)			
	Initial state	Economic decisions	Natural causes	Multiple causes	Final state
Land cover					
Σ					

(Source: SEEA, 2000)

The figure can be translated into tables like tables 2.1 to 2.4. The table 2.1 shows the land use/land-cover matrix on the basis of the classification of land as an economic asset (land use) and the ecosystem part (cover) of the SEEA asset classification. Table 2.1 can be further expanded to show the land use activities matrix and the land use and land cover changes.

Table 2.1. Land use/land cover

		Land Use				
	Land cover	Land underlying building and structures	Agricultural land	Forest Land	Major water bodies	Other land
	Urban					
	Agricultural					
	Forest					
	Grasslands					
	Barren lands					
Terrestrial	Other					
	Costal					
	Rivers					
	Other					

From the stock accounts in Table 2.1, time series on opening or closing stocks can be established. From this the net flows between different categories of stocks can be found. However, for the interpretation of changes in the fields of land accounting, gross flows (areas increasing the stock of a category during a period and areas decreasing it) are especially important from an ecological point of view because the replacement of sold stocks of parts of nature (old part of a forest) by new stocks (afforestation) is normally linked to a considerable loss in ecological quality. In general two levels of changes can be distinguished: changes between categories of land use or land cover (external changes, changes in classification) and changes within categories (internal changes). External changes are described in the core accounts. They can be described to a certain extent by more detailed classifications of land use and cover. Internal changes will typically be described in supplementary accounts. In Table 2.2 the stock accounts are expressed in terms of its relation to different economic activities. Here land is treated as a production factor and not as part of balance sheets.

Table 2.2. Land use by industries and private households

	Land use				
Industries and private households	Land underlying buildings and structures	Agricultural land	Forest land	Major water bodies	Other land
Agriculture, hunting, forestry, fishing					
Mining quarrying					
Manufacturing, electricity					
Construction					
Wholesale, retail trade, repair motor vehicles, hotels and restaurants					
Transport, storage, communication					
Financial intermediation					
Education, health, social, personal services					
Public admin, defense, social security, other public services					
Private households					

The land cover changes matrix (table 2.3), cross-tabulates land cover at two different points in time providing a detailed insight into the external changes. The same analysis can be done for land use changes. It shows how much of the opening stock of a land cover category is still the same in the closing stock and the gross flows between the different categories of land cover. The total increase, the total decrease, the total change (increase + decrease) and the net change (increase – decrease) can be deduced from this table. The production of such a table has normally to be based on georeferenced data sources because single data for the same unit cover in the opening stock (initial year) and in the closing stock (final year) must be known and analyzed.

Table 2.3. Land cover changes matrix

Land cover (initial year)	Terrestrial	Urban	Agricultural	Forest	Grasslands	Barren lands	Other lands	Total (initial))year)	Decrease
Terrestrial ecosystems									
Urban									
Agricultural									
Forest									
Grasslands									
Barren lands									
Other lands									
Total (final year)									
Increase									
Total changes (increase + decrease)									
Net change (increase – decrease)									

The analysis of the causes of changes in Table 2.4 is restricted to external changes. This type of data is actually better available for land cover than for land use. For every category of land cover, the initial stock (opening stock) and the final stock (closing stock) are identified. If they are different, the change is allocated to a type of change according to fixed allocation rules.

Table 2.4. Changes in land cover by categories of changes

		Increase									Decrease									
Land cover	Initial stock	Changes due to economic decisions	Urbanisation	Changes in agricultural practices	Restoration and rehabilitation	Changes due to other causes	Multiple causes	Natural causes	Catastrophic causes	Total	Changes due to economic	Urbanisation	Changes in agricultural practices	Restoration and rehabilitation	Changes due to other causes	Multiple causes	Natural causes	Catastrophic causes	Total	Final stock
Terrestrial ecosystems																				
Urban																				
Agricultural																				
Forest																				
Grasslands																				
Barren lands																				
Other lands																				
Total (final year)																				

In the next section we see the scope of implementing the above framework for Tamilnadu. We first examine the data availability and then see whether or not it is feasible to implement the suggested framework for land resources (arrange the available data in the form of tables 2.1 to 2.4). If it is not feasible to arrange the data in the suggested manner, we explore an alternative way to adjust the national accounts.

2.2. Operationalising the framework for Tamil Nadu

2.2.1. Profile of Tamil Nadu

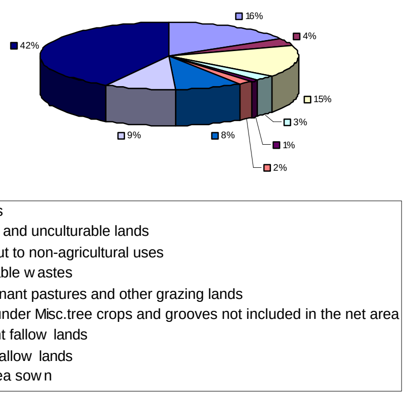
Tamil Nadu, the southern most state of the Indian peninsula is spread over 1,30,058 Sq. Km. It lies between 80° 5"S to 130° 35" N latitude and 760° 15" W to 800° 20" E latitude and accounts for about 4 percent of the total area of the country. The topography of Tamil Nadu broadly consists of the coastal plains in the east; uplands and hills as one proceeds westward. The plains account for more than half the area of the state. As Tamil Nadu has a tropical climate, loss of water due to evaporation is considerable. The State is exposed to both South West and North East Monsoons. Most of Tamil Nadu is located in the rain shadow region of Western Ghats and hence receives limited rainfall from South West Monsoon. The coastal districts receive more rainfall from North Eastern monsoon but its contribution is irregular since the rainfall is caused primarily by cyclonic storms in Bay of Bengal. The North Eastern Monsoon (October-December) contributes 47.4% of rainfall while South West

(June- September) accounts for only 33.3%. The remaining 19.3% occurs during the transition period from January-May. High intensity of rainfall during monsoon periods sometimes brings heavy floods in the rivers and causes damage to crops, properties and lives affecting the economy of the State. On the other hand, failure of monsoon also causes crop loss, affecting lives of cattle and human population. Cyclonic storms in the coastal belt occur during North East monsoon almost every alternate year bringing heavy rainfall in the coastal belt once or twice which is not beneficial but causes inundation of crops, drainage congestion etc.

2.2.2 Land use pattern in Tamil Nadu

Table 2.5 gives the nine-fold land use classification for Tamil nadu in various years. This classification is primarily based on whether a particular area is cultivated, grazed or forested and is based on actual use and not based on how a particular piece of land can be potentially utilized (see Annexure 1 for definitions). It is clear that agriculture and forests are the major land users in the State, accounting for more than fifty per cent of the land use. However the agricultural land has decreased from 61% of the geographical area in the 1970s to 46% in 2002-03 while the area under forests more or less remained the same. It should be remembered that in case of forests the area officially recorded as forests may not have changed but the actual tree cover would have changed. The extent of fallow lands and land put to non-agricultural uses has also increased between 1970s and 2002-03. The implications of the changes in land utilization will be discussed in detail in the coming chapters. The detailed land use classification in different districts for the year 2001 is given in Table 2.5. The description of various heads is given below:

Land Use Pattern in Tamil Nadu (2000 -2001)



a) Forests

In Tamil Nadu, Dharmapuri district ranks the first with a forest cover of 3,66,226 hectares. This works out to 17.2% of the state's total forest area. This is followed by Erode district with 2,28,750 hectares 81.7%. The Nilgiris district has about 56.3% of the total area as forests followed by Dharmapuri with 38.0%. Dharmapuri, Erode, Vellore, Cimbatore, Thiruvannamalai, The Nilgiris, Dindigul, Salem, Tirunelveli and Theni disctricts account for 79.8% of the total forest area of the state.

b) Barren and unculturable land

In Tamil Nadu, an extent of 4,75,850 hectares of land comes under barren and unculturable land category, which represents 3.7% of the total geographical area of the state. Villupuram district alone accounts for 57,297 hectares which is 12% of the state's barren and unculturable land and about 7.9% of its geographical area is under this category. The area under this category is very meager in Thiruvarur district with 0.2% of the total geographical area.

c) Land put to non-agricultural uses

The lands occupied by buildings, pathways, roads, canals and land put to uses other than agricultural purposes are brought under this category. Area under this classification is 19,78,320 hectares accounting for 15.2% of the state's geographical area. The extent under this category has increased by 10,555 hectares during the year under report as compared to 1998-99. In Kancheepuram district about 14,1750 hectares of land are put to non-agricultural uses, which is the highest in the state (7.2%) followed by Pudukottai with 1,28,103 hectares (6.5%). In Chennai district about 98.3% of its geographical area is put to non-agricultural uses.

Table 2.5. Land Use Pattern in Tamil Nadu (Area in Lakh ha.)

S.No	Classification	1970's	1980's	1990's	2000-01	2001-02	2002-03
1	Total Geographical area	130.06	130.06	130.16	129.91	129.91	129.91
2	Forest area	20.05	20.76	21.44	21.34	21.32	21.32
3	Barren and Uncultivable land	7.05	5.57	4.95	4.75	4.77	4.78
4	Land put to Non-agricultural uses	16.00	17.95	19.07	19.86	19.98	20.12
5	Cultivable Waste	4.15	3.08	3.25	3.52	3.87	3.89
6	Permanent Pastures and other grazing lands	1.98	1.45	1.25	1.23	1.18	1.18
7	Land under misc. tree crops and groves not included in the net area sown	2.15	1.82	2.25	2.55	2.71	2.78
8	Current fallow lands	12.02	16.18	10.57	11.34	10.26	15.03
9	Other fallow lands	5.31	7.03	10.93	12.28	14.09	14.91
10	Net area sown	61.35	56.22	56.32	53.03	51.72	45.9

d) Culturable Waste

The total area under culturable waste is 3,48,640 hectares of 2.7% of the total geographical area of the state. Tirunelveli, Karur, Thoothukudi, Sivagangai, Dharmapuri, Tiruchirapallu, Tiruvannamalai, Villupuram, Pudukkottai and Thanjavur districts account for nearly 72% of the area under this category. The area of culturable waste is very meager in Kanyakumari district with 0.04% of the state's geographical area.

e) Permanent Pastures and other grazing lands

All grazing lands, whether they are permanent pastures or meadows are considered as permanent pastures. An extent of 1, 22,585 hectares or 1.0% of the geographical area of the state falls under this category. The extent under this category is the highest in Kancheepuram district with 18,317 hectares followed by Dharmapuri district with 13,668 hectares under this classification ranks first contributing 14.1% of the total area of the state under this category.

f) Current fallow lands

The cultivable lands, which are kept fallow during the entire period under review, are known as current fallows. The area under current fallow during 1999-2000 constituted 8.4% of the total geographical area of the state. The extent is highest in the Coimbatore and Erode districts, which together accounted for 24.6% of the total are of the state under this category.

g) Land under miscellaneous tree crops

Lands under Casuarinas trees, thatching grasses, bamboo bushes and other groves for fuel etc., which are not included under orchards, are classified under this category. The extent is 2,42,990 hectares or 1.9% of the geographical area of the state. Thoothukudi district with 34,223 hectares under this classification ranks first contributing to 14.1% of the total area of the state under this category.

h) Other fallow lands

All lands which are taken up for cultivation but have temporarily put off cultivation for a period of not less than one year and not more than fiver years are treated as other fallow lands. An extent which is 8.8% of the total geographical area, has been recorded under this category as against 11,10,728 hectares during he previous year. The land under other fallow land is the highest in Tirunelveli district with 24.5% of the total area under this classification and ranked first contributing 14.7% of the total area of the state under this category.

i) Net area sown

Net area sown represents the area sown with crops during the year only once. Out of the 1,29,91,322 hectares of geographical area, 54,64,376 hectares of land constituting 42% was cultivated once with various crops during the year 1999-2000. Tiruvarur district ranked first contributing 72.7% of its geographical area towards this category followed by Cuddalore with 62.7%, Thanjavur district with 59.8%, Perambalur with 58.4%, Namakkal with 58%, Nagapattinam with 55.9% and Salem with 49.8% respectively.

2.2.3. Developing Physical Accounts for Land in Tamil Nadu

Based on the information available from various sources we now try to conceptualize the framework (Tables 2.1 to 2.4) discussed in earlier section. As discussed earlier, we need two sets of data. One on the stock side to establish the relation between land use and land cover and land use by economic activities and secondly, the change of land cover versus land use in terms of gross flow between two points in time and analysis of different types of changes. We try to examine the feasibility of constructing land use accounts in the form of Tables 2.1 to 2.4.

To arrange the data in the form of tables 2.1 to 2.4, we need information of land cover and land use changes. We obtained this data from various secondary sources. Of all the sources, we relied mainly on the information provided by the National Remote Sensing Agency (NRSA). The NRSA published report on "Area Statistics of Land Use/Land Cover generated using remote Sensing Techniques in 1995 based on the information collected for the year 1988-89" for different districts of Tamil nadu. Land Use/Land Cover maps were prepared based on 1:250,000 scales using IRS-1A satellite data for around 442 districts in India under different agro-climatic zones. Other than this, NRSA has not carried out any new survey, which gave detailed information for the state of Tamil Nadu. In order to construct the land accounts, we need two different data points. Hence, to get the end point we relied on a study done by Institute of Remote Sensing (IRS), Anna University on "Identification of Recharge Areas Using Remote Sensing and GIS in Tamil Nadu" published in 1998-99. This report gives Land use and Land cover information in different districts of Tamil Nadu, prepared based on 1:50,000 scale using IRS-IC satellite data. The scale of the two studies are different but in the absence of any other study which give detailed land use and land cover classification for different districts in Tamil Nadu we used the estimates from these two reports. However, the information on land use by industries and private households is not available. Hence, we could not adjust the data in the format given in table 2.2. Table 2.6 gives the Land Cover and Land use of Tamil Nadu in 1988 – 89 based on the data published by NRSA (1995). The description of various terms is given in Appendix 1. Table 2.7 gives the Land Cover and Land use of Tamil Nadu in 1998-99 based on the information published in the report "Identification of Recharge Areas Using Remote Sensing and GIS in Tamil Nadu". However, the report published did not include three districts of Tamilnadu. The table has been adjusted for these three districts based on the nine-fold classification of land given in Table 2.2, and is given in Table 2.8.

Despite all the adjustments we found that there is a difference in the resolution of the imagery between the two years. The classification under major heads has not been uniform. Moreover, there has been lot of inconsistency between geographical area as recorded by the land utilization statistics and the one recorded by remote sensing. However, in the absence of any other information we had to utilize this information to illustrate the framework for land and water resources in Tamil Nadu. Even after adjusting we could not proceed with the framework suggested by SEEA as the classification of land use is very different as can be seen from the tables. For this reason we had to use only the major land use classification. Table 2.9 gives the land use change matrix for Tamil nadu for the years 1988 to 1998 based on the information provided by NRSA ad Table 2.10 gives the land use change matrix for Tamil nadu based on the nine fold classification during 1998 to 2003. There is no match between the data provided by NRSA and nine-fold classification.

Table 2.6 Land Cover and Land Use of Tamil Nadu in 1988 – 89 (Area in Sq. km)

	Land cover						
Land Use	**Built up Land**	**Agriculture**	**Forest**	**Wastelands**	**Water bodies**	**Others**	**Total**
Built -up Land	6143.51	-	-	-	-	-	**6143.51**
Settlement							
Industrial Area							
Air Strip							
Agricultural Land							
Net Area Sown	-	70152.04	-	-	-	-	**70152.04**
Fallow	-	10679.10	-	-	-	-	**10679.10**
Agri. Plant.	-	5241.33	-	-	-	-	**5241.33**
Forest Land							
Ever Green Forest	-	-	1469.09	-	-	-	**1469.09**
Deciduous Forest	-	-	4638.04	-	-	-	**4638.04**
Degraded Forest	-	-	8498.68	-	-	-	**8498.68**
Forest Blanks	-	-	0	-	-	-	**0**
Forest Plant.	-	-	1468.07	-	-	-	**146807**
Mangrove Forest	-	-	64.40	-	-	-	**64.40**
Waste Land							
Salt Affected Area	-	-	-	595.41	-	-	**595.41**
Water Logged Area	-	-	-	294.59	-	-	**294.59**
Marshy/ Swampy Area	-	-	-	234.34	-	-	**234.34**
Gullied/ Ravenous area	-	-	-	112.55	-	-	**112.55**
Land with or without Scrubs	-	-	-	10792.26	-	-	**10792.26**
Sandy Area	-	-	-	1425.95	-	-	**1425.95**
Barren Stony/ Sheet Rock Area	-	-	-	767.30	-	-	**767.30**
Water Bodies							
River/ Streams	-	-	-	-	3889.05	-	**3889.05**
Lake/ Reservoir/Canal	-	-	-	-	3326.50	-	**3326.50**
Others							
Shifting Cult.	-	-	-	-	-	0	**0**
Grass/ Grazing	-	-	-	-	-	28.14	**28.14**
Salt Pans	-	-	-	-	-	161.99	**161.99**
Mining Area	-	-	-	-	-	75.66	**75.66**
Unclassified	-	-	-	-	-	0	**0**
Total	**6143.51**	**86072.47**	**16138.28**	**14222.40**	**7215.55**	**265.79**	**130058.00**

Source: NRSA (1995)

Table 2.7. Land Cover and Land Use of Tamil Nadu in 1998 – 99 (Area in Sq.km)

	Land Cover						
Land Use	**Built -up Land**	**Agriculture**	**Forest**	**Wastelands**	**Water bodies**	**Others**	**Total**
BUILT-UP LAND							
Settlement	3069,07						**3069,07**
Industrial Area	106.65						**106,65**
Air Strip	30.37						**30,37**
AGRICULTURE							
Crop Land		27614.96					**27614,96**
Fallow/Harvest/		2909.83					**2909,83**
Wet Crop Land		8752.60					**8752,60**
Dry Crop Land		7946.22					**7946,22**
Plantation		31711.87					**31711,87**
FOREST							
Dense Forest			3385.75				**3385.75**
Open Forest			5126.82				**5126.82**
Degraded Forest			8331.19				**8331.19**
Grass Land			81.02				**81.02**
Forest Plantation			1557.25				**1557.25**
Mangrove Forest			335.89				**335.89**
WASTELANDS							
Scrub Land				5133.89			**5133,89**
Salt affected land				275.99			**275.99**
Gullied Land				277.08			**277.08**
Water Logged/ Swampy				7.86			**7.86**
Sandy Area				75.77			**75.77**
Barren Land				4771.06			**4771.06**
Steep Slope				429.32			**429.32**
Rock Outcrop				516.79			**516.79**
WATER BODIES							
River/stream					1796.97		**1796.97**
Reservior/Tank					6833.18		**6833.18**
Tank with Plantation					593.49		**593.49**
OTHERS							
Problems Soil						1326.08	**1326.08**
Mining Land						28.42	**28.42**
Industrial Waste						2.38	**2,38**
Salt Pan						223.66	**223.66**
Reclaimed Land						1.96	**1.96**
Tidal						36.54	**36.54**
Sand Features with vegetation						768.79	**768.79**
Total	**3206.09**	**78935.48**	**18817.91**	**11487.78**	**9223.64**	**2387.83**	**124058.73**

Source: Identification of recharge areas in Tamil Nadu (various districts), 1998

Table 2.8. Adjusted Land Cover and Land Use of Tamil Nadu in 1998 – 99 (Area in Sq.km)

Land Use	Built -up Land	Agriculture	Forest	Wastelands	Water bodies	Others	Total
BUILT-UP LAND	6623,29	0,00	0,00	0,00	0,00	0,00	6623,29
Settlement	6340,2	0,00	0,00	0,00	0,00	0,00	6340,23
Industrial Area	220,3	0,00	0,00	0,00	0,00	0,00	220,32
Air Strip	62,7	0,00	0,00	0,00	0,00	0,00	62,74
AGRICULTURE	0,00	78935,48	0,00	0,00	0,00	0,00	78935,48
Crop Land	0,00	27317	0,00	0,00	0,00	0,00	27317,47
Fallow/Harvest/	0,00	3717	0,00	0,00	0,00	0,00	3716,75
Wet Crop Land	0,00	8658	0,00	0,00	0,00	0,00	8658,31
Dry Crop Land	0,00	7861	0,00	0,00	0,00	0,00	7860,62
Plantation	0,00	31382	0,00	0,00	0,00	0,00	31382,33
FOREST	0,00	0,00	**21400**	0,00	0,00	0,00	21400,00
Dense Forest	0,00	0,00	3789	0,00	0,00	0,00	3789,10
Open Forest	0,00	0,00	6052	0,00	0,00	0,00	6052,36
Degraded Forest	0,00	0,00	9247	0,00	0,00	0,00	9247,21
Grass Land	0,00	0,00	210	0,00	0,00	0,00	210,04
Forest Plantation	0,00	0,00	1728	0,00	0,00	0,00	1728,47
Mangrove Forest	0,00	0,00	373	0,00	0,00	0,00	372,82
WASTELANDS	0,00	0,00	0,00	**11487,76**	0,00	0,00	11487,76
Scrub Land	0,00	0,00	0,00	5479,8	0,00	0,00	5479,84
Salt affected land	0,00	0,00	0,00	259,8	0,00	0,00	259,77
Gullied Land	0,00	0,00	0,00	260,8	0,00	0,00	260,80
Water Logged/ Swampy	0,00	0,00	0,00	7,4	0,00	0,00	7,40
Sandy Area	0,00	0,00	0,00	71,3	0,00	0,00	71,32
Barren Land	0,00	0,00	0,00	4518,1	0,00	0,00	4518,11
Steep Slope	0,00	0,00	0,00	404,1	0,00	0,00	404,09
Rock Outcrop	0,00	0,00	0,00	486,4	0,00	0,00	486,42
WATER BODIES	0,00	0,00	0,00	0,00	9223,64	0,00	9223,64
River/stream	0,00	0,00	0,00	0,00	1796,97	0,00	1796,97
Reservior/Tank	0,00	0,00	0,00	0,00	6833,18	0,00	6833,18
Tank with Plantation	0,00	0,00	0,00	0,00	593,49	0,00	593,49
OTHERS	0,00	0,00	0,00	0,00	0,00	2387,83	2387,83
Problems Soil	0,00	0,00	0,00	0,00	0,00	1326,08	1326,08
Mining Land	0,00	0,00	0,00	0,00	0,00	28,42	28,42
Industrial Waste	0,00	0,00	0,00	0,00	0,00	2,38	2,38
Salt Pan	0,00	0,00	0,00	0,00	0,00	223,66	223,66
Reclaimed Land	0,00	0,00	0,00	0,00	0,00	1,96	1,96
Tidal	0,00	0,00	0,00	0,00	0,00	36,54	36,54
Sand Features with vegetation	0,00	0,00	0,00	0,00	0,00	768,79	768,79
Total (in Sq.km.)	6623,29	78935,48	21400,00	11487,76	9223,64	2387,83	130058,00

2.9 Land use change matrix for Tamil Nadu during 1988-89 to 1998-99 (in sq.km)

Land Use	Built -up Land	Agriculture	Forest	Wastelands	Water bodies	Others	Total
Built-up land	**479,78**	0	0	0	0	0	**479,8**
Agriculture	0	**-7136,99**	0	0	0	0	**-7137,0**
Forest	0	0	**5261,72**	0	0	0	**5261,7**
Wastelands	0	0	0	**-2734,64**	0	0	**-2734,6**
Water bodies	0	0	0	0	**2008,09**	0	**2008,1**
Other lands	0	0	0	0	0	**2122,04**	**2122,0**
Total	**479,78**	**-7136,99**	**5261,72**	**-2734,64**	**2008,09**	**2122,04**	

Table 2.10 Land Utilisation in Tamil Nadu based on the nine-fold classification (000 hectares)

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**Change during 1998-2003**
Recorded Forest Area	2140	2134	2134	2132	2132	2122	-18
Barren and Unculturable land	478	476	476	477	478	509	31
Land put to nonagricultural use	1968	1978	1986	1998	2012	2113	145
Culturable waste	348	349	352	387	389	379	31
Permanent pastures and other grazing lands	123	123	123	118	118	113	-10
Land under miscellaneous tree crops and groves not included in the net area sown	240	243	255	271	278	283	43
Current fallows	956	1085	1134	1026	1503	954	-2
Other fallow lands	1111	1140	1228	1409	1491	1863	752
Net area sown	5635	5464	5303	5172	4590	4689	-946
Total geographical area by village papers	12998	12991	12991	12991	12991	130027	26

To utilize the information provided in tables 2.9 and 2.10 in the format suggested by SEEA, we need to reclassify the information into Opening stocks, Changes due to economic activity, Other accumulations, Other volume changes and Closing stocks. For constructing detailed accounts, we need uniform data for different years. However, it is not available. For example, for forests we need information on growing stock of forests between different years and the area under different forests, area subject to afforestation, regeneration, forest fires etc. However, the Forest survey of India has changed the resolution of the satellite imagery to 1:50,000 from 2001. Earlier the resolution was 1:150,000. As the resolution is not uniform it may not lead to accurate assessment. The estimates of forest cover provided by Forest Survey of India for the years 2001 and 2003 does not tally with the land use change matrix shown above in Table 2.10. The FSI data shows that forest cover in Tamil nadu has increased whereas based on the land use classification matrix it is shown as decrease. Similarly, for the first time waste lands have been mapped using satellite imagery in 1998 and the report has been published in 2000. The latest report on wastelands is for the year 2005. The forest data is not available for the same years. These wastelands would have resulted as a degradation of land due to unsustainable land use practices. Hence, the agricultural and pastureland data was taken for the previous 10 years. In the end, we arrive at per hectare values and try to monetise the land use change matrix. For the purpose of illustrating ways to incorporate forest resources in the SEEA framework, I used the data for the assessment period 2001 – 2003.

Hence, in this report, the framework to incorporate land resources into national accounts is discussed separately for various categories of land cover and land use. Henceforth, in the coming chapters no reference to the land use change matrix (given in tables 2.9 and 2.10) is given but we will examine the feasibility of linking all the tables in the final chapter. In chapter 3 we account for forest resources and in chapter 4 we account for agricultural, pasture land and waste land. In chapter 5 we try to account for water resources. Integration with the national accounts has been discussed separately in each chapter.

Chapter 3. Physical and Monetary accounts for forests using SEEA framework

3.1. Profile of forests in Tamil Nadu

As per the assessment made by Forest Survey of India in 2003, the forests contribute to around 16.5% of the state's geographic area and constitute 3.2% of the country's forest cover. The district wise forest cover in Tamil nadu is given in Table 3.1. Dharmapuri district with an extent of 3,66,226 hectares under forests is the highest among districts in their contribution to the forest area of the state. This works out to 17.2% of the state's total forest area. This is followed by Erode district with 2,28,749 hectares (10.7%). The unique feature of the Nilgiris district is that about 56% of the total area of the district is under forests followed by Dharmapuri with 38.0%. Dharmapuri, Erode, Vellore, Coimbatore, Tiruvannamalai, The Nilgiris, Dindigul, Salem, Tirunelveli and Theni Districts accounted for 79.8% of the total forest area of the state.

There is a very minor change in the recorded forest area statistics from 2001 to 2003. The total forest and tree cover has increased by 98 km^2. There is a shift from the reserved forest area to the protected forest area. The protected forest area has decreased from 2,240sq. km in 2001 to 2,183 sq.km in 2003 and the reserved forest area has increased from 19,325 sq. km in 2001 to 19,388 sq.km in 2003. There are also minor variations in the percentage of variation of the state's geographic area and the country's forest area. The country's forest area has decreased by 0.5%. Significant changes can also be observed in the tree cover pattern.2001 accounted for 6,054 km^2 of the tree cover, this has drastically declined to 4,991 km^2 in 2003, of which Culturable Non-forest Area (CNFA) has declined by 4917 km^2 and the number of trees per ha of CNFA has declined by 1.5. The total tree cover has declined by 1063 km^2.

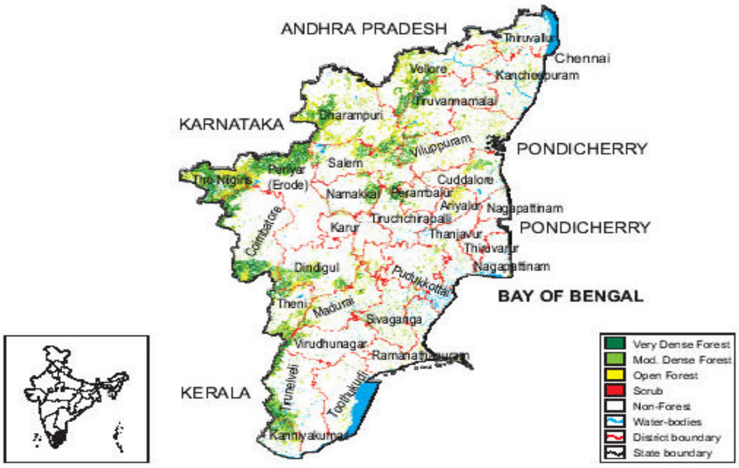


Figure 1. The Map depicting forest cover in Tamil Nadu

3.2 Physical Accounts for forestland using SEEA framework

A) Opening stocks

The opening stocks represent the area categorized as forested land present at the beginning of the accounting period (2001 assessment). The forest area is categorized into three types: very dense (crown cover greater than 70%), dense forests (crown cover between 40 – 70%) and open forests (crown cover between 10 to 40%). The opening area is taken from the State of Forest Report (2001).

B) CHANGES IN FORESTED LAND

The opening stock can change due to increase in the stock (due to afforestation and natural expansion), decreases in the stock due to deforestation and degradation and changes in classification and reassessment of stocks.

B1. Afforestation and natural expansion

The stock of forested land may increase because of the establishment of new forest on land, which was previously not classified as forested land (afforestation) or as a result of silvicultural measures or natural expansion (natural regeneration). The afforested area and compensatory afforestation[7] in Tamil Nadu is available from various forest statistical reports. In addition there is also some amount

[7] If a hectare of forest is cleared it is mandatory to afforest at least two times the area deforested. This is termed as compensatory afforestation.

of regeneration in forests. The area regenerated (naturally and artificially) is obtained from ICFRE (2000).

B2. Deforestation and degradation

The stock of forested land may decrease because of the complete loss of tree cover and transfer of forested land to uses other than forestry (agricultural land, land under buildings, roads, etc.) or to no identifiable use. This is usually a result of deforestation from human activities. The stock may also be reduced because the forested land is degraded to a point where tree cover falls below 10 per cent and the land thus becomes classified as other wooded land. Sometimes the dense forests may become open forests because of excessive harvesting. Though the total forest cover may not decrease, in reality degradation may have taken place leading to an increase in open forest cover. Degradation may appear for natural reasons, for reasons of human activity or for a combination of reasons. Total removals of standing timber by felling are not decreases in forested land if the use of the land does not change after felling. However if it leads to degradation of forestland it should be included.

The elements considered under changes in forested land are deforestation (transfer of land to non-forest purposes), degradation due to logging, forest encroachments, heavy grazing (leading to degradation of forests thereby resulting in closed forests being classified as open forests and open forests classified as scrubs). The data on forest encroachments is taken from ICFRE (2000). In India there is a ban on clear felling and hence area deforested due to logging is taken as zero. However, there is lot of logging and the amount of area degraded as a result of logging activity is recorded.

Some of the forest area is transferred for non-forest purposes. The area transferred for non-forest purposes are compiled from forestland use change matrix between the years 2001-03. Shifting cultivation has not been considered as the state of Tamil nadu does not have any area under shifting cultivation.

B3. Changes in classification and reassessment of stocks

Changes in classification due to economic decisions include declaring a forest area as a protected area or canceling the protected area status enabling the forested land to be opened up for different uses, categorizing unclassed forests which are inaccessible due to difficult forest terrain or protected forests due to changes in the conditions of the infrastructure etc. Reassessment of the stock due to improved knowledge includes recognition of new resources and adjustments of area and volume estimates due to new data and estimation methods (for example, changes in resolution of the satellite imagery etc.) Catastrophic events (fires, storms, etc.) affect the volumes of standing timber on forested land, although they do not necessarily decrease the forested land area. However, the data published in 2001 and 2003 are based on the same resolution and hence this element is not considered.

C. Closing Stocks

The closing stocks are computed as opening stocks less reductions plus additions. Any difference with the exact closing stocks as per the 2003 assessment is recorded under errors and omissions.

3.2.2 Physical accounts for timber and carbon

A. Opening Stocks

The opening stocks represent the growing stock of timber present at the beginning of the accounting period (2001 assessment). To convert this estimate into units of carbon, we need the estimates of biomass. As estimates of biomass using direct measurement (destructive sampling) are not available for all forest types in the country, a study by Haripriya (2000b, 2002a) used the volume inventory data to estimate the carbon content of the biomass in different states and different types of forests (see Haripriya, 2000b). The biomass data are converted to carbon values by assigning a carbon content of 0.5 Mg C per Mg oven dry biomass. According to the study, the carbon density/ha varies in different states from 3.4 to 171.8 t C/ha with an average carbon density/ha of 42 tC/ha. We have included only the aggregate carbon content of forest biomass and do not include the stock of carbon in soils. The rationale for including this is that we are interested in the change in carbon as a result of “disturbance” on forested land in the current accounting period.

B. Changes Due to Economic Activity

Changes due to economic activity refer to human production activities such as logging/harvest (recorded and unrecorded), logging damage, forest encroachments, shifting cultivation and afforestation that affect (decrease/increase) the stock of forests. The recorded volume of timber harvested/logged can be derived from the production statistics of timber and fuel wood obtained from the CSO for the year 2002-2003. However the volume harvested for timber and fuel wood is highly debated as the estimated consumed volume exceeds the recorded produced volume. A considerable amount of timber and fuel wood goes unrecorded due to illegal felling of trees. The statistics on the number of trees cut illicitly and the loss in revenue due to illicit logging is available with various state forest departments (SFD) and the revenue generated from the seizure of illegal material is recorded in the production statistics. However, a considerable amount of timber and fuel wood still goes unrecorded. In order to account for unrecorded production, the CSO uses an estimate of 10% of the total recorded production of industrial round wood as the value of unrecorded production of industrial round wood (which is an approximate estimate). For fuel wood, the CSO estimates the unrecorded removals of fuelwood by superimposing the trend of fuel wood consumption observed from the NSSO consumption surveys for the year 1983-84 on the estimates for 1980-81 prepared on the basis of recorded production (See CSO, 1989). Despite accounting for unrecorded production based on the norms set by CSO, on tallying the volume accounts at the end we found that some growing stock is still missing. So we accounted for some of this difference in the growing stock as unrecorded removal, which could not be tracked by the forest department. A study by Gundimeda et al. (2006a) made an assumption that if it is recorded in the national accounts, it is no longer unrecorded production and only the differences in the growing stock (not tallied) can be treated as unrecorded production. The same assumption has been used in the present study. As logging involves logging damage, the study considers logging damage as well. Damage due to logging is assumed to be 10% of the volume of timber logged from both recorded and unrecorded production.[89] We assumed that some of the damaged timber leaves the forested land because deadwood is collected for use as fuel. The remaining timber is left on-site but is assumed that it is an economic loss.

The statistics on afforestation reported at the state level though indicate some species planted, but we do not have exact information on the growing stock of these species and the survival rate of these plantations. This makes the task of estimating the volume added due to afforestation difficult and so the study estimates the volume additions due to afforestation by multiplying the area afforested with the mean annual increment per sq. km and assume that the same conditions prevail at the existing sites. Such an assumption has been made by some of the earlier published studies by the Haripriya (1998, 2000, 2001), Atkinson and Gundimeda (2006), Gundimeda et al. (2006a). The volume additions due to afforestation are derived by multiplying the area afforested with the mean annual increment per sq. km of forests.

While developing timber accounts is quite straightforward, accounting for carbon needs a careful analysis because any disturbances on forests involve flux of carbon between the atmosphere, soils and forest products. When forests are subjected to various disturbances, some of the carbon remains in the forest biomass itself, some remains *in situ* (in the forests on the floor or transferred to soils) and a part of it is transferred to the atmosphere as CO_2, CO and CH_4. The proportion of carbon transferred to the atmosphere, soil etc are based on disturbance matrices (given in Haripriya, 2003). Some of the carbon enters the forest product sector and the carbon that has been left onsite enters the soil carbon pools. These fluxes between the forest, atmosphere, soils and forest products need to be taken into account before accounting for carbon. A study by Haripriya (2003) has developed the carbon balance accounts

[8] Unrecorded production refers to extraction of timber without proper records, illegally and detected theft.

[9]The figure is based on the information provided by the state forest department of Maharashtra (visited on May 28th 1997)

for India using a simulation model which takes into account all carbon pools and fluxes. Our study uses the estimates from Haripriya (2003) and incorporates the carbon estimates into the national accounts. Atkinson and Gundimeda (2006), Gundimeda et al. (2006a), Gundimeda et al. (2005a) also develop the carbon accounts based on these estimates.

In short, while computing the total volume of carbon lost or gained due to changes in economic activity, one should include a) carbon transferred to forest products (in the form of biomass); b) releases of carbon from forest biomass into the atmosphere while clear cutting or forest fires; and c) releases to soil pool. As the timber can be logged either by clear felling or partial cutting, one has to consider the respective carbon balances by different methods. Haripriya (2003) has assumed that when the logging is done by clear-cutting only 80% of the stem biomass is transferred to the wood products, whereas 2% remains on the stem, 8% is transferred to soils and 10% is released to the atmosphere. When the forest is subject to partial cutting 85% of the stem biomass is transferred to wood products, 10% remains on the stump and 5% is transferred to the soils. The amount of carbon remaining on the stem or transferred to soils gives the amount of logging damage[10]. Another point to be noted here is that from the standpoint of national accounting, Atkinson and Gundimeda (2006) have defined the change in carbon as the amount of carbon released arising from disturbances (e.g. logging) on forested land in the current accounting period. The same assumption has been made in this report.

The volume lost due to shifting cultivation is obtained by multiplying the area subject to shifting cultivation with the growing stock per ha in open forests. The total carbon released as a result of shifting cultivation includes a) releases from forest biomass into the atmosphere and b) transfer to the soils. Here we have assumed that 80% of the carbon is transferred to the wood products and the rest is released. Forests in Tamil Nadu are affected by encroachments. The volume lost due to encroachments is computed similarly. [11]

C. Other Accumulations

Other accumulations consist of the accumulation of timber due to natural growth (mean annual increment), natural regeneration, and the transfer of forestland for non-forest uses (for example, for

[10] One can argue that the carbon remains on the stump even without the cutting. As per the discussions with the officials of the forest departments, some of the portion remains on the tree while harvesting and damaged as the tree cannot be uprooted totally. This is categorized as logging damage because the tree cannot grow again nor can be used for any purpose. It is equivalent to dead tree. The carbon will be released from it in course of time.

[11] We made any assumption that forest encroachments usually happen on the periphery of open forests. So the growing stock in open forests needs to be used for calculations.

agriculture, residential or industrial purposes). The mean annual increment of different species is taken from the statistics published by the FSI (1995b). This volume estimate is converted to units of carbon using the same method as discussed earlier.

In addition there is also some amount of regeneration in forests. The area regenerated is estimated from the forest change matrix. The volume added due to regeneration is computed by multiplying the area regenerated with the mean annual increment per ha of different species.[12] Some of the forest area is transferred for non-forest purposes. The volume reduction due to transfer of land for nonforest purposes is derived by multiplying the area transferred with the growing stock per ha. Here we assume that there is some standing timber left on the forestland before the land is converted to non forest purposes. This timber may be used in various wood products from which the carbon will be released depending on the use to which it is put to.

D. Other Volume Changes

Other volume changes comprise reductions (due to stand mortality, insect infestation, forest fires and natural calamities). Fires can be of two types: ground fires (non-stand replacing) and crown fires (stand-replacing). As the ground fires are non-stand replacing fires they are not considered under other volume changes and only the stand replacing fires are considered. The area subject to forest fire is given by ICFRE (2000). We assume that only regenerated and afforested volume of young trees is affected by stand replacing forest fire. The volume of forest stock affected by forest fire is derived by multiplying the naturally regenerated volume and the afforested volume with the percentage area affected by the forest fire.[13] Haripriya (2003) estimated that when the forest is affected by fires, only 20% of the stem biomass remains, 50% is burnt and the carbon transferred to the soils (immediate and releases that eventually occur in future as a result of fires today) and 30% is released into the atmosphere.

As pests infect the forests, only insect infestations resulting in loss of biomass are explicitly considered in the study. Every year the forests are degraded because of grazing. The percentage area subject to grazing is available from the SFR (1995). We have considered only the area subject to heavy grazing because this leads to forest degradation. The volume lost due to grazing is derived by multiplying naturally regenerated volume and the afforested volume with the percentage of area subject to heavy grazing. However, no carbon loss is assumed from grazing because the carbon

[12] As a result of frequent fires and heavy grazing only 18.3% of the total forest area has regeneration potential of important species (FSI, 1995a).

[13] Only the forest area that is prone to frequent fires is considered as affected by fire annually in this study.

increases due to regeneration (if any) on the grazed land is assumed to be offset by loss in carbon due to surface fires and grazing.

E. Closing Stocks

The closing stocks are computed as opening stocks less reductions plus additions. Any difference with the exact closing stocks as per the 2003 assessment is recorded under errors and omissions.

Table 3.1. District-wise Forest Cover in Tamil Nadu) as per the latest State of Forest Report - 2003

District	**Geographic area**	**Forest Cover**				**Percent**	**Change w.r.t 2001 assessment**
		Very Dense	Moderately Dense	Open Forest	Total Forest		
Ariyalur	1,947	0	28	255	283	14.54	-71
Chennai	144	0	3	3	6	4.17	1
Coimbatore	7,469	405	833	566	1,804	24.15	12
Cuddalore	3,706	0	185	248	433	11.68	35
Dharmapuri	9,622	193	1,051	1,710	2,954	30.70	259
Dindigul	5,580	63	662	541	1,266	22.69	98
Erode	8,209	378	1,174	678	2,230	27.17	83
Kancheepuram	4,474	0	106	271	377	8.43	-23
Kanyakumari	1,684	78	253	204	535	31.77	30
Karur	2,901	0	13	75	88	3.03	11
Madurai	4,277	31	197	303	531	12.42	17
Nagapattinam	2,140	0	16	37	53	2.48	-25
Namakkal	3,413	40	294	217	551	16.14	31
Perambalur	1,748	9	54	67	130	7.44	10
Pudukottai	4,651	0	81	157	238	5.12	15
Ramanathapuram	4,232	0	101	134	235	5.55	18
Salem	5,232	67	528	539	1,134	21.66	30
Sivaganga	4,086	0	169	309	478	11.70	-2
Thanjavur	3,415	0	60	69	129	3.78	59
The Nilgiri	2,549	404	878	789	2,071	81.25	48
Theni	2,764	89	405	337	831	30.07	107
Thiruvallur	3,413	0	62	160	222	6.50	1
Tiruvarur	2,716	0	10	16	26	0.96	4
Thiruchirapalli	4,511	69	153	172	394	8.73	22
Tirunelveli	6,810	203	549	347	1,099	16.14	50
Tiruvanamalai	6,191	165	478	672	1,315	21.24	123
Toothkudi	4,621	0	46	106	152	3.29	7
Vellore	6,077	165	608	920	1,693	27.86	235
Villipuram	7,190	27	431	598	1,056	14.69	-42
Virudhunagar	4,283	54	139	136	329	7.68	18
Total	130,058	2,440	9,567	10,636	22,643	17.41	1,161

Source: State of Forest Report (2003)

3.3 Value of forest goods and services

Before developing monetary accounts it is important to understand the value of forests. Forests provide multiple benefits to the economy. The values can be categorized into use values, non-use values, existence values and option values. The use values come directly from use of forest goods like timber, fuel wood, fodder, non-timber forest products, recreation etc. Non-use values can be services like carbon sequestration, ground water recharge, flood prevention, prevention of soil erosion etc. In addition to these values forests are also valued for their mere existence. These are called as existence values. In addition, some people may value forests because of the possibility that in future they may provide some use value. This is called as option value. For example, forests may be storehouse of pharmaceuticals. It is possible that in future they will provide valuable drug to the economy. Different methods are used to value different goods and services. In this report an attempt is made to value forests for timber, fuelwood, fodder, nontimber forest products, ecotourism and option value of pharmaceuticals. Below I briefly explain the methods I used in obtaining the value of timber, fuelwood, carbon fodder, nontimber forest products, ecotourism and bioprospecting values.

3.3.1. Value of Timber and Fuelwood

The prices realized per cubic metre of timber for different states are obtained from the CSO who in turn compiles the figures based on the information provided by various state forest departments. The most common form of revenue generation is through royalties or auctions. From this the costs of logging are deducted to obtain the resource rent. The costs include logging, pre-logging and post-logging costs, transportation costs and overhead costs, some of which differ by the extractable log volume and the logging methods (see Haripriya, 1998 for more details on different costs). The costs of logging for different states are also obtained from the CSO.

3.3.2 Value of Carbon

For valuing the carbon sink services, marginal social damage or abatements cost approaches can be used. Marginal social damage costs refer to the economic value of the damage caused by the emission of an additional metric ton of C to the atmosphere. Abatement costs refer to the costs of maintaining/reducing carbon emissions. They are extremely variable depending on the abatement measure being considered. For example, for forestry projects under the CDM, the abatement costs are the production costs of growing/conserving the forests to capture or avoid CO_2 emissions. Frankhauser (1994,1995), Frankhauser and Tol (1996), and Tol (1999) discuss the wide range of marginal social damage costs estimated by various authors, which average approximately US $20/MTC. There are well established carbon markets now, and one can use this estimate as well. However, as the carbon prices fluctuate depending on the volume of trade, one can use an average price. While developing the monetary accounts for carbon in this report, we used an estimate of \$20/tC for valuing carbon releases (Atkinson and Gundimeda, 2006). This can be treated as an upper bound. Moreover, it should be noted that forests can be valued either for timber or carbon and not both. We need to make an assumption about what proportion of forests has to be valued for timber and what proportion for carbon. In this report, we made an assumption that the reserved forests are used for carbon sequestration services and the protected forests for timber, fuelwood, ntfps and fodder.

3.3.3 Value of NTFPs

The value of ntfps per hectare is computed from the statistics provided by the CSO. As the only input required in collecting NTFPs are the labor and it is mostly those who has no opportunity to work elsewhere are involved in collection, the cost of inputs are considered to be zero. However, the value of NTFPs is severely undervalued because in India, the residents of forest villages have the privileges to collect all ntfps for their bonafide personal use or earning livelihood. This makes the task of finding the exact value of ntfps very difficult. The CSO approximately takes the value of unrecorded NTFP production as 10 times the value recorded by the State Forest Department (SFD)[14].

3.3.4 Value of Fodder

The forests also provide fodder for the livestock. The fodder has market value but it is largely undervalued. Hence, the value of fodder obtained from forests is valued using the cost of alternate acreage as used in Haripriya (2000a). In the absence of well-developed market for cultivated fodder, the value is determined as the opportunity cost of allotting alternate acreage to it (Munshi and Parikh, 1990). This is equivalent to loss in revenue from agriculture due to cultivating equivalent amount of fodder obtained from forests on agricultural land. To estimate the value of fodder, it has been assumed that the total leaf fodder production in the country is 4.9 tons of dry matter and the grass production is 3 tons per hectare (see, Tewari, 1994). Further, the study makes the assumptions that only 2% of the leafy biomass is utilized as fodder (NCA, 1976). The amount of land required to grow fodder grazed in forests is computed as the ratio of total fodder grazed in forests and the average yield of fodder on agricultural lands. The report on the Committee on Livestock Feeds and Fodder, NCA (1976) estimated fodder yields as 50 tons/ha of irrigated land and 25 tons/ha of unirrigated land. The ratio of irrigated to unirrigated area in different states is used to obtain the average yield of fodder on agricultural lands. The opportunity cost of land in different states is derived as the ratio of the agricultural GDP to the gross sown area ratio in each state.

[14] No adequate explanation has been provided for using this norm. CSO has initiated some studies to revise this estimate.

3.3.5 Value of Ecotourism

As forests provide tourism benefits, the best way to approximate the value of protected areas is through exploring their potential value as a source of nature recreation (also called eco-tourism). The ecotourism value can be captured through estimating the consumer surplus per hectare per tourist either through contingent valuation method or travel cost method which involve collecting information from different sites and tourists. Consumer surplus is referred to as net willingness to pay, or willingness to pay in excess of the cost of the good. Consumer surplus can be viewed equivalent to a virtual market price for a recreation activity. A study by Gundimeda et al. (2006b) used an approach called benefit transfer method to estimate the value of ecotourism in Indian forests. “Benefit transfer” refers to the use of existing information and knowledge to new contexts, i.e., adapt and use information from already existing secondary studies in India on ecotourism to different protected parks in India. In this report the values have been taken from the study by Gundimeda et al. (2006b). A summary of methodology adopted by the study is given below:

The study first compiled consumer surplus estimates from different studies (which estimated recreational value of national parks in India) and regressed it on the site-specific variables of these studies. The study got the following equation for domestic and foreign tourists respectively.

PCS (domestic) = - 0.063 + 47.85*fauna per hectare – 0.69*dummy for method + ε ------------ (1)

PCS (foreign) = -0.39 + 300.1*fauna per hectare – 4.36*dummy for method + ε ------------- (2)

Keeping all other variables at their mean values, the study used the actual number of fauna per hectare in different states to obtain the consumer surplus per tourist per hectare for domestic and foreign tourists visiting the state. The per hectare consumer surplus was multiplied with the total tourists visiting the park and the area of the park to get the total consumer surplus.

However as tourists visit multiple destinations, the share of consumer surplus attributable to national parks alone has to be found out. So the study by Gundimeda et al. (2006b) estimated the share of consumer surplus attributable to national parks by fitting a regression between number of tourists in a particular state and the variables influencing tourism (like dummy for religious places, national parks, beaches, number of tourist attraction, popularity of the place, connectivity etc) separately for domestic and foreign tourists. The total consumer surplus per tourist per hectare is obtained by multiplying the consumer surplus per hectare with the share of consumer surplus attributable to national parks to get the total consumer surplus per ha. As the study used the consumer surplus estimates as a proxy for income we deducted the amount of expenditure incurred to protect, maintain and upkeep the national parks and Sanctuaries to get the net price. To compute the amount of expenditure incurred the study used the amount sanctioned under the following programmes: Biosphere reserves, Project tiger, Project elephant, Eco development project, Development of National Parks and Sanctuaries, Central zoo Authority and Protection of Wildlife in India to different states during 2001-2002, as an approximation of the costs of providing and maintaining the national parks.

Further, the study has also assumed that the numbers of tourists are growing at the rate of 9.2% as per the projections made by the World Tourism Council for different countries till 2020 and then the ecotourism growth stabilizes at 2020 levels. The net present value of ecotourism is obtained by using a discount rate of 4%. A study by Gundimeda et al (2006b) estimated the ecotourism and bioprospecting values of Indian forests. This report borrows the values from the study to estimate the ecotourism and bioprospecting values of Indian forests. However, we valued only dense forests for the ecotourism and bioprospecting values.

3.3.6 Bioprospecting Value of Forests

One of the most important services that biodiversity provides to the economy is in the form of provision of genetic material. In the developed world some 25 percent of all medicinal drugs are based on plants or their derivatives; however this number is three times higher in developing countries. Losing any species can be very risky because we do not know what we are losing. For the genetic materials, which are already discovered values exist but are mostly under valued due to market imperfections. If we want to know whether the conservation of a species is worthwhile, we need to know the value of undiscovered genetic material.

A study by Gundimeda et al (2006b) used an approach called the value of marginal species, i.e. the contribution that one more species makes to the development of new pharmaceutical products (termed as marginal value). The marginal value is the incremental contribution of a species to the probability of making a commercial discovery. This approach is based on a paper by Rausser and Small (2000). In this report the same approach by Gundimeda et al (2006b) has been used. The model can be summarized as follows:

- The forest area in the country is partitioned into K classes of varying quality(the study by Gundimeda et al. (2006b) assumed that each state is different in terms of quality of forest cover and its potential).
- Suppose that one such parcel of land contains a lead for a drug, which may carry a genetic material to cure some disease. A single lead in the study corresponds to land parcels of a uniform area (1,000 hectares), where an investigator can collect biological samples.
- The quality of the lead is based on some pre-conceived notion. The quality of a parcel as a potential source of new drugs is defined as the density of endemic higher plant species in that

ecosystem, measured as the average number of species per hectare or density of all species or density of medicinal plants. In this paper we assumed all the three but the final results are based on the assumption that the density of medicinal plants determines the lead quality.

- The ability to discover a lead is based on the probability of a hit, which in turn is dependent on the quality of the forestland. This probability has been assumed to be a constant (represented by p_n). P_N is the probability of the lowest hit in the sample.
- There is also a probability that no drug is discovered. It is called the probability of failure (given by a_n). The probability that a project will terminate unsuccessfully, exhausting the available leads without yielding a discovery, is $\prod_{k=1}^{18}(1-\bar{p}.e_k)^{N_k}$. Here N_k denotes the number of sites in the ecosystem. a_N corresponds to the failure of the lowest probability of hit in the sample.
- Given the costs of R&D (C) and Revenue R, the bioprospecting value is given by

$$v_n = \left\{\left(\frac{a_n}{a-p_n}(p_n - p_N)R + \left[\sum_{i=n+1}^{N-1}\frac{a_i}{a-p_n}(p \quad - p_i)\right]c\right)\right\} + a_N(p_N R - c) \quad \text{-------------------- (3)}$$

The first term in brackets is the information rent. The first component of this term represents the increase in expected benefit associated with a higher probability of obtaining a hit before exhausting all leads. The second component in square brackets represents the drop in expected costs of search that will no longer be needed if a hit is made earlier. Thus information rent will depend upon a particular lead's success probability compared to the success probabilities of other leads. To estimate this model, information on the annual turnover of pharmaceutical companies which use plant based raw materials, their research and development costs, the administrative and management costs, the probability of a hit, the number of species in each state, the endemic species and the species of medicinal importance, the number of leads, new drug approvals each year and the discount rate is needed.

In the equation (3) the last term is the scarcity rent of a lead. This is in fact the value of a marginal lead since it is the expected amount that would contribute to the value of a project if all leads were substitutes for one another, ex ante. As long as the number of leads is finite and we expect that random screening is profitable, then the scarcity rent will be positive.

The net present bioprospecting value of the nth lead is then given by

$$\sum_{t=0}^{\infty} l(1+r)^{-t} v_n = l v_n / r \qquad \text{…………. (4)}$$

where ? is the number of projects initiated to yield a successful drug.

3.4 Monetary Accounts for Forests

Once the value of different goods and services are established, asset value of forests can be derived using the net price method. The net price method assumes that the value of resource at the beginning of period t (V_t), is the volume of the opening stock (R_t) multiplied with the difference between average market value per unit of the resource (P_t) and the per unit marginal cost of harvest, development and exploration (C_t) and is given by $V_t = (P_t – C_t)R_t$. As I could not get marginal costs of extraction I used average costs. The values of timber, fuelwood, carbon, ntfps, ecotourism and biodiversity used to derive the monetary accounts are given in Table 3.5.

Once the value of the opening stocks and closing stocks are determined by net price method, the value of depletion can be calculated by adding subtracting the value of the opening stock from the value of the closing stock. As forests yield non-timber forest products (in addition to timber), value accounts of NTFPs are derived by multiplying the area accounts with the discounted value per hectare of the products (see Haripriya 2001). The monetary accounts for ntfps can be derived by multiplying the area accounts with the present value per hectare of the products (NTFPs and fodder). Once the value of the opening stocks and closing stocks are determined by net price method, the value of depletion can be calculated by subtracting the value of the opening stock from the value of closing stock. For ecotourism and biodiversity values, only the dense forests are assumed to have these values as open forests are mostly monoculture plantations and do not have much biodiversity values.

The monetary accounts are separately constructed for timber and fuelwood, carbon, ntfps, ecotourism and bioprospecting values (see Table 3.6 and 3.7). Various volume entries in the physical accounts are multiplied with the net price of (timber and fuel wood) to obtain the flow values. The monetary for timber, carbon are given in table 3.6 and the monetary accounts for services ecotourism and bioprospecting are given in table 3.7.

Table 3.2. Profile of forests in Tamil Nadu

Recorded forest area	**Area (in Sq.kms)**
Reserved forest	19388
Protected forest	2183
Unclassed forest	1306
% of Geographical area	17.59
Total Recorded forest area	22877
Forest cover (in Sq.kms)	22643
Very dense forest	2440
Moderately Dense forest	9567
Open forest	10636
% of geographical area	17.41
Growing stock	
Volume (000 cum)	88702
Volume per ha (cum/ha)	39.2

Source: State of Forest Report (2003)

Table 3.3. Physical accounts for forested land for the years 2001 – 03

	Area in hectares
Opening stocks	**2148200**
Open forests	*898300*
Closed forests	*1249900*
Changes in forest land	
Total changes in forest land	***116100***
Changes in closed forests	*-49200*
Changes in open forests	*165300*
Causes of changes	
Natural/artificial regeneration	*381468*
Afforestation	*80417*
Deforestation	*0*
Shifting cultivation	*0*
Forest degradation (reclassification)	*-345785*
Closing area of closed forests	***1200700***
Closing area of open forests	***1063600***
Closing stocks	**2264300**

<u>Table 3.4. Volume Accounts for Timber, Fuelwood and Carbon</u>

	Volume accounts for timber (000 cum)	Carbon accounts (000 tC)
Total opening stock	87250.6	93756
Changes due to economic activity (+/-) (A)	6499.3	-5671
Recorded logging (-)	958	5711
Unrecorded logging (-)	4410.3	39
Logging damage (-)	536.8	
Afforestation (+)	36.4	0
Forest encroachments (-)	78.2	
Shifting cultivation (-)	0	0
Animal grazing (-)	552.8	
Other volume changes (-) (B)	3.7	0
Forest fires (-)	0.7	0
Stand mortality (-)	3.0	0
Other accumulations (C)	7070.3	7597
Natural growth (+)	3495.0	3756
Regeneration (+)	3575	3842
Transfer of land to other activities (-)	0	0
Omissions and errors (+/-)	884	
Net volume change (A+B+C)	1451.5	1244
Total Closing stock	88702.0	95316

Table 3.5. Value of timber, fuelwood, ntfps and fodder used in the estimates (in Rs)

Net price of timber (Rs/cum)	35416
Net price of fuelwood (Rs/MT)	730
Value per hectare of ntfps (in Rs)	113
Net present value of ntfps (in Rs)	2818
Value of fodder (per ha)	283
Net present value of fodder (per ha)	7079
Net price of carbon (per tonne)	Rs. 900 (US$20)
Value of ecotourism per hectare	8,425
Net present value of ecotourism per hectare	210641.2
Value of bioprospecting per ha*	3000.5
Net present value of bioprospecting per ha	75,014

* - value based on the assumption that the search is carried over medicinal plants
Source: Gundimeda et al. (2006a, b)

Table 3. 6. Monetary accounts of forests (timber, carbon and ntfp values) in Rs. Millions

	Monetary accounts for timber and fuelwood	Carbon accounts (000 tC)
Total opening stock	661703	84380.7
Changes due to economic activity (A) (+/-)	-49291	-5104,3
Logging/harvest+unrecorded logging (-)	40710.5	5139.5
Logging damage (-)	4071.0	
Afforestation (+)	276.3	35.2
Forest encroachments (-)	593.1	0
Shifting cultivation (-)	0	0
Animal grazing (-)	4192.1	0
Other volume changes (B) (-)	28	0.3
Forest fires (-)	4.9	0.3
Stand mortality (-)	23.1	0.01
Other accumulations (C)	60247.3	7682.8
Natural growth (+)	33132.6	4225.1
Regeneration (+)	27114.6	3457.6
Transfer of land to other activities (-)	0	0
Omissions and errors (+/-)	79.1	
Net volume change (A+B+C)	11008	1403.7
Total Closing stock	672711	85784

Table 3.7. Monetary accounts of forests (ntfps, ecotourism and biodiversity) (in Rs. Millions)

	Monetary accounts for ntfps	Ecotourism	Biodiversity
Total opening stock	21260	2,63,280	93,760
Changes due to economic activity (A) (+/-)	+1149.0	-10,364	-3691
Closing stocks	22409	2,52,916	90,069

The monetary accounts suggest that the value of the total stock of timber was about 1451.4 million rupees higher at the end of the accounting period and viewed in terms of carbon 1560 million rupees higher, than at the beginning of the period. This is because in the state of Tamilnadu while the total forest area has increased by 0,12 million ha, the dense forest cover has decreased by 49200 ha and open forests have increased by 165300 ha thereby leading to higher stock of timber and carbon. This increase in forest cover has been mainly due to regeneration and afforestation and the decrease has been due to forest degradation due to economic activities. Similarly, due to this increase in physical stock, the value of forests from ntfps has also increased. However, viewed from the perspective of ecotourism and biodiversity, the stock of forests has decreased by 10364 million rupees and 3691 million rupees respectively. There has been an increase in the wealth of forests if we value it only for timber, fuelwood and nontimber forest products. However if we value forests for other services like ecotourism and biodiversity, there is a loss in forest wealth. The net effects need to be recorded in the national accounts.

3.5. Integration with the National Accounts

In the final step we integrate our estimates with the national accounts. Here in this report we have chosen to focus on adjustments to Gross/Net State Domestic Product (GSDP/NSDP). Our forest accounts provide more accurate figures for forestry affecting three components of the national accounts:

1) figures for the production of timber that adjust unreported production. This will increase (or decrease) both GDP and NDP by the amount of the 'missing' timber.

1) Capital accounts that expand

a. capital formation to include accumulation in natural forests and depletion. In the conventional accounts, only accumulation of produced capital is included. Natural forests, which are called non-produced assets, are excluded. We add the value of accumulation of natural forests to investment, which increases GDP/GSDP and NDP/NSDP.

b. Consumption of capital to include the cost of depletion of natural forests, which decreases NDP/NSDP.

It should be noted that while the first adjustment is completely consistent with the SNA and represents simply a better estimate of conventional national income, the second set of adjustments is outside the SNA and represents SEEA revisions to the SNA. This second set of adjustments is particularly important when natural forests are converted to non-forest purposes, the income from logging is recorded in GDP and NDP, but the decline in asset value is recorded only under other volume changes which does not have any impact on GDP or NDP. As we discussed earlier, when forests are logged (above the mean annual increments) or converted to non-forest purposes, potential values of the forests are lost and need to be accounted for rather than just accounting for the income from harvesting.

The result of these adjustments is the environment adjusted state domestic product (ESDP)

$ESDP = NSDP + (A_{np} - D_{np})$

Where D_{np} is the depletion of nonproduced natural assets and is obtained from the asset accounts.

The asset accounts are constructed as follows:

Closing stocks – Opening stocks = changes due to economic activities ± Other accumulations ± other volume changes ± omissions and errors

Depletion = other accumulations ± changes due to economic activities

The second term captures the net effects of accumulation natural forests (non-produced assets, A_{np}) minus depletion (D_{np}).

The summary of these calculations are given below in table 3.8.

Table 3.8. Integrated forest accounts for 2002-03 (in Rs millions)

GSDP	1537287
NSDP	1367809
Value added by timber and fw in the national accounts	5853.6
Value of ntfps in the national accounts	242.1
Value of timber and fw in this study	22390.8
Value of ntfps as per the study	242.1
Value of grazing	93.1
Adjusted GSDP	1553824
Adjusted NSDP	1382522.8
Depletion of timber	-5504
Depletion of carbon	-701.6
Depletion of ntfps	574.5
Depletion of ecotourism	5182
Depletion of biodiversity	1845.5
ESDP	1377794.5
ESDP/adjusted NSDP	1,00

Table 3.8 gives the integrated national and forest accounts for Gross State Domestic Product (GSDP), Net State Domestic Product (NSDP) and Environment-adjusted State Domestic Product (ESDP). The gap between GSDP and ESDP indicates the extent of environmental degradation caused due to economic activity. If the ratio of ESDP to NSDP is greater than or equal to 1, growth is sustainable otherwise the growth has come at the expense of environmental degradation for these states.

From Table 3.8 it can be seen that in the state of Tamilandu the impact on net state domestic product of the changes in the forest cover has not been much. There has been an increase in value of forests due to timber, fuelwood and nontimber forest products due to increase in the overall forest cover. However, the value of forests has decreased due to loss in the ecotourism and biodiversity values arising from loss in dense forest cover. But overall, the net impact on NSDP has not been much which means that the growth has been more or less sustainable. This conclusion however is based on the given data and given set of assumptions. Existing national and state accounts do not factor in changes in value due to additions and reductions in forest stock, an essential data point to assess whether a state economy is sustainable (within the context of ‘weak sustainability’) after accounting for forest losses.

4. Framework for Accounting for Agricultural, Pasture Lands and Waste Lands

4.1. Profile of Agriculture in Tamil Nadu

Agriculture sector occupies a key place in fulfilling food requirement of growing population, meeting raw material requirements of agro-based industries and providing employment to majority of the rural population. Agriculture is a significant contributor to Gross Domestic Product (GDP) in Tamil Nadu as is the case with India. The share of agriculture declined from 24.6% of the state GDP in the 1980s to 21.8% in 1990s before declining to the current level of 16.9% (*Tamil Nadu – An Economic Appraisal, GOTN*). However, unlike in mature economies where the percentage of population dependent on agriculture declines in proportion to the decline in contribution to the GDP, this phenomenon has not occurred on the same scale in Tamil Nadu. Still about 60% of the population depends directly or indirectly on Agriculture. Therefore, growth in this sector becomes important. Though in recent years some declining trends are observed because of the recurrent drought, food security has been reached almost fully.

Tamil Nadu has an area of 1.3 Lakh sq.km with a gross cropped area of around 63 lakh hectares. The size of the average landholding is declining consistently and currently it is 0.93 ha, compared to 1.55 hectares at an all India level. Moreover, out of 80 lakhs of total operational holdings, 59.51 lakhs holdings are less than 1 ha, and 12.3 lakh holdings fall between 1-2 hectares. The cropping intensity is hovering around 119% and the irrigation intensity is around 120%. The factors responsible may be extreme pressure on land due to variation in rainfall and urbanization. The net sown area has declined over the last 10 years from 55.8 lakh ha to 45.9 lakh ha. The cultivable area also declined from over 81.6 lakhs ha to 79.7 lakh ha. With the cropping intensity remaining around 118 to 120% and came down to 113% during 2002-2003, the gross cropped area declined from over 66 lakh ha too little over 51 lakh ha and in the past 10 years period it has been no-where near the cultivable area of around 80 lakh ha. The changes in land use patterns from 1950s to 2001 is given in Table 4.1.

The state aims to bring second green revolution in dry land Agriculture, while sustaining the tempo of agricultural development in irrigated agriculture. The change in land use pattern created serious concern among the agricultural planners to evolve suitable development strategies. The increasing trend of fallow lands (both current and other fallows), which was 22.93 lakh hectares during 1990-91 to 24.35 lakh hectare during 2001-02 which has further increased to 29.93 lakh hectares and 28.17 lakh hectares during 2002-03 and 2003-04 respectively due to drought situation caused reduction in cropping intensity from the average level of 120% to 113% during last 2 years. The gross cropped area declined to 53.16 lakh hectares during 2003-04, from the average normal coverage of 63 lakh hectares leaving about 9.8 lakh hectares under fallow.

Table 4.1: Land Utilisation and cropping pattern intensity in Tamil Nadu

Sl.No	Items	1990-91	1995-96	2000-01	2001-02	2002-03
1	Total area	130.19	130.04	129.91	129.91	129.91
2	Culturable waste	2.90	3.48	3.52	3.87	3.89
3	Current fallows	12.49	12.93	11.34	10.26	15.02
4	Other fallows	10.44	11.30	12.28	14.09	14.91
5	Net area sown	55.78	53.42	53.03	51.72	45.90
6	Cultivable area (2+3+4+5)	81.61	81.13	80.17	79.94	79.72
7	Area sown more than once	10.57	9.25	10.34	10.53	6.01
8	Gross cropped area (5+7)	66.32	62.67	63.38	62.26	51.91
9	Cropping intensity	118.90	117.30	119.50	120.30	113.10
10	Ratio of net sown area to cultivable area (5/6) % (indicating extent of use of cultivable area)	68.34	65.84	66.15	64.70	57.60

Source: i. Development Indicators for Tamil Nadu.

ii. Season and Crop Report of Tamil Nadu by Commissioner, Department of Economics and Statistics.

Though the reduction of cropped area during 2003-04 is evidently more due to acute drought that prevailed during that year, still there is reduction in gross cropped area to the tune of around 4 lakh hectares between 1990-91 to 2001-02. The main crops grown in different districts of Tamil Nadu are given in Figure 4.1 and the agricultural performance of the state is given in Table 4.2.

Table 4.2. Agricultural performance of the state

Crop	Average Yield		Highest yield in India	Tamil Nadu's Place
	India	Tamil Nadu		
Rice	1804	3350	3510(Punjab)	Second
Jowar (Cholam)	769	962	962(Tamil nadu)	First
Bajra (Cumbu)	610	1348	1348(Tamil nadu)	First
Red Gram	616	710	1301(Bihar)	Fourth
Total food grain	1562	2238	3830(Punjab)	Fourth
Total Oil seeds	710	1611	1611(Tamil Nadu)	First
Groundnut	733	1784	1784(Tamil Nadu)	First
Cotton	193	305	410(Punjab)	Third
Sugarcane	64562	106778	106778(Tamil Nadu)	First

Source: Agricultural Statistics at a glance 2004 – Agricultural Statistics Division – GOI

Figure 4.1: Tamilnadu Agricultural Map.

In terms of productivity despite the drought stress, Tamil Nadu continues to occupy the top place or near the top in All India ranking. An All India level comparison of productivity of different crops shows that Tamil Nadu tops in the case of groundnut, total of the various types of oil seeds, sugarcane, Cholam and Cumbu with an average yield per hectare of 1765 kg, 1500 kg, 107.29 tonnes, 1010 kg and 1518 kg, respectively. The state also ranks second in the productivity of rice with 3415 kg, next only to Punjab (*Agricultural Statistics at a Glance, 2002, GOI*).

ISSUES AND CONSTRAINTS FACING THE AGRICULTURE SECTOR

The major constraints to achieve a sustainable growth in agriculture in the State are:

- Extensive pressure on land due to urbanisation.
- Fragmentation of land holdings.
- Frequent failure of monsoon and uneven distribution of rains.
- Depletion of ground water due to over exploitation and lack of recharge.
- Increasing area under fallows.
- Degradation of land (problem soils).

• Declining nutrient status of soil and soil health due to intensive cultivation and traditional crop husbandry activities more specifically relating to irrigation and nutrient application.
• Declining ground water levels and uncertainty in release of river water due to its lower riparian status.
• Inadequate focus on dry land farming (52% of the cultivated area is rain fed).
• Continuing marketing problems.
• Severe drought during the past three years.

4.2. Framework for Accounting

At first I suggest the framework for physical and monetary accounts (land cover, land use and production) for different states and union territories in India. We assess the period 1991 to 2000. The reason why we used a ten year time frame is that, sometimes agricultural land can remain fallow for reasons other than economic causes (for example, for factors due to failure of monsoon). Moreover, the unsustainable use of land will not result in degradation of land immediately. It occurs over a period of time. As the wasteland data is published in the year 2000 based on the assessment carried till 1999, we felt that this time period can sufficiently capture the land use pattern as well. Such a framework and assumption has been made by Gundimeda et al. (2005b). In this report, the same methodology has been adopted. Finally, we annualize our results to the annual loss due to degradation by applying a 'straight line' method. By accounting for land resources we are also accounting for the soil resources on the land because the value of land depends on whether or not the soil is fertile. The methodology used in Gundimeda et al. (2005b) is discussed in the following sections and the results are operationalised for Tamilnadu.

4.2.1 Physical Accounts

The physical accounts for agricultural and pasturelands under SEEA framework include items such as opening and closing stocks, other accumulation, and other volume changes (Table 4.3). Opening and closing stocks refer to the quantity of land (area in hectares) at the beginning and end of the accounting period. The increase in land area under agricultural and pastureland can be made (artificially) for economic reasons- by means of land reclamation (from the sea or river beds). Increase or decrease in the quantity of land come under the other accumulation category, which simply pertains to the changes in the quantity of land (additions or reductions in areas devoted for specific use) caused by economic decisions. Included in this category are changes in land use and/or transfers of non-economic land from the environment into the economy for production purposes and vice-versa. Lands subjected to shifting cultivation involve areas that are opened up for agriculture from forestry and, thus, represent additions to the inventory. On the other hand, conversions from agricultural to non-agricultural uses would decrease agricultural areas and increase other types of land. Quantitative losses of land due to economic uses can be caused due to partition of states or transfer of districts to some states etc. or in some cases due to natural disasters (eg : river/sea coastal erosion ; in case of river erosion, in states such as Assam, the area lost is not inconsiderable ; or for example due to the December 2004 Tsunami, which submerged large portions of arable land). As such, these changes are entered in the category *other volume changes*. An *adjustment* was included in the physical accounts to balance the resulting *closing stock* of the previous year to the *opening stock* of the following year.

Due to unsustainable practices, some of the land becomes degraded and is categorized as wasteland. These lands comprise of salt affected lands, lands subject to chemical deposition, lands subject to shifting cultivation, gullied and ravenous land, waterlogged lands etc., which can have an affect on productivity. In this report the wastelands are not separately accounted for but are accounted as part of changes in agricultural land use. As some amount of wasteland exist, only the wasteland arising out of land use changes due to economic activities are specifically accounted for.

Table 4.3. A Framework for accounting for agricultural and pasture lands

Activity	
Opening stock	Land under cultivation and grazing
Changes in quantity	Asset increase due to land reclamation/improvement
Other accumulation	Changes in land-use Transfer of land from the environment to economic use
Other volume changes	Changes in land use and land area due to natural, political or other non-economic causes Transfer of land from economic use to environment
Closing stock	Land under cultivation or grazing
Changes in quality of land*	Soil erosion or nutrient loss (tons) Land/soil contamination including salinization and other changes in soil quality
Impact on other sectors of the economy**	Extent of sedimentation in water-ways Amount of GHGs released to the atmosphere Extent of contamination of waterways by pesticides and fertilizers

Changes in land and soil quality affect land productivity and economic value, the most notable of which is topsoil erosion measured in tons of soil lost, which affects the productivity of agricultural lands. The physical extent of lands for general and specific uses is accounted for in the supplementary accounts and is expressed in hectares. Specifically, the land use account represents physical area by specific type of land use and land utilization.

In the next step we try to bring the information into the accounting framework mentioned in Table 4.3. The opening stock of agricultural and pastureland is taken as the opening area (net area sown) in the year 1991. The closing stock is the stock of agricultural land present at the end of 2000 (net area sown). The area under agricultural and pastureland is taken from the Agricultural Statistics published by the Ministry of Agriculture. The land use change matrix has been obtained from the land use classification in different years as published in the Tamilnadu economic appraisal and Statistical Abstract of Tamil Nadu. As seen in Table 4.3 the stock can change due to several reasons. The stock can change due to economic reasons or changes in the quantity of land under particular land use or transfers from environment to economic uses. Such detailed information is not available from published data. Only land use change data is available which is shown in Table 4.4.

Table 4.4. Land use change matrix between the years 1992-93 – 2000-2001(000 ha)

Reporting area for land utilization statistics	Land under forests	Area put to non-agricultural uses	Barren & Uncultivable land	Permanent pastures & Other grazing land	Land under misc. tree crops and groves	Cultivable waste land	Fallow lands, other than fallows	Current fallows	Net area sown
-21	-17	117	-34	2	24	48	177	172	-510

Source: Author’s compilation based on the data from Tamilnadu statistical abstract

For example in Tamil Nadu the area put to agricultural use decreased by 17,000 ha. This decrease could be as a result of increase in the area put to non agricultural uses (see the definitions in Annexure 1) or due to improvement of land which was earlier unfit for cultivation. All the changes in land use classification basically imply other accumulations. Reliable data on changes due to economic activity is not available. Hence, we have not dichotomized the cause of the changes between the opening and closing stocks. This does not effect our estimates because any change in agricultural land or pastureland is reflected in the total production and hence the value. If the agricultural land increases due to whatever the reason, it is reflected in increased production and vice versa. If this increase in agricultural area has come because of land improvements, the investments on this land improvement have already been recorded by CSO in gross capital formation (GCF). If the agricultural land is converted to nonagricultural uses it indicates decrease in the capital in the agricultural sector but increase in value in other sector, which should be accounted for in the other sector.

From Table 4.4 it can be seen that in Tamilnadu, there has been decline in agricultural land mostly due to conversion to fallows.

4.2.3 Estimating the value of land degradation

If the land is used sustainably, it has an infinite life therefore no adjustment for degradation is required and the whole resource rent can be considered as income. However, as discussed earlier the use of land for agriculture using unsustainable practices would mean degradation of land due to soil erosion in the form of loss of nutrients from the topsoil, movement of soil (changes in soil depth), salinization due to improper irrigation practices, deposition of chemical fertilizers on land etc. This results in degradation of lands. However, not all lands are necessarily because of unsustainable land use practices. It may be because of natural geography like terrain, coastal regions etc. Table 4.5 gives the change in wastelands between the years 1998 to 2003. For the purpose of construction of accounts only the waste lands arising as a result of agricultural practices has to be considered.

Table 4.5: Categorization waste lands of Tamilnadu in 2000 and 2005 (sq.kms)

Year	G&R	WL&ML	S/AL	SH/C	UU/DF	DPG	DPC	S&DL	M&IWL	BR/SA	SSA	SC/GA	Total waste lands	% Total geograph-ical area
2000	226.1	415.8	2479.7	0.53	9634.25	168.94	221.96	590.8	120.46	1155.92	301.5	0	23013.9	17.7
2005	169.7	388.3	890.5	0	8131.5	115.3	78.58	1019.7	207.41	1164.41	198.14	0	17303.3	13.30

Source: Waste land Atlas of India (2000, 2005), Dept. of Land Resources, Ministry of rural Development, Govt. of India

BR/SA Barren Rocky/Stony Waste/Sheet Rocky Area
DPG Degraded Pastures/ Grazing Land
DPC - Degraded Land Under Plantation Crops&
GL&R Gullied & or Ravenous Land
M&IWL Mining Industrial Wastelands
S/A Land affected by Salinity/Alkanity-Coastal/Inland
SC Snow Covered and or Glacial Area
S&DL Sands- Desertic Coastal
SH/C Shifting Cultivation Area
SSA Steep Slopping Area
UU/DF Under Utilized Degraded Notified Forest Land
WL&ML Water Logged & Marshy Land
US Upland with or without Scrub

Further, the degradation of land can have onsite impacts in the form of loss in valuable top soil leading to productivity loss and also offsite effects in the form of water sedimentation. Not only this, the productive land may be degraded resulting in increase in wastelands. The physical accounts for land use and land quality use are given in Table 4.6.

Table 4.6. Physical Accounts for Agricultural and Pasture Lands in Tamil Nadu 1992-2001

	Opening stocks	**Changes in quantity**	**Closing stocks**
Agricultural Land (000 ha)	5813	-510	5303
Pasture Land (000 ha)	352	26	378
Waste Lands (sq.km)[1]			
Gullies and Ravines	226.1		169.7
Upland with or without scrub			
Waterlogged and marshy land	415.8		388.3
Salt affected land	2479.7		890.5
Degraded pastures or grazing lands	168.94		115.3
Shifting cultivation	0		0
Soil erosion (Mt/yr)[2]	153.3		
Onsite impact			
Nitrogen loss	0.059		
Phosphorous loss	0.133		
Potassium loss	2.046		
Off-site impact			
Water sedimentation (Mt/yr)	0.501		

Note: 1. The wasteland data is for the period 1998 –2003
2. The soil is assumed to be lost uniformly for all the years and is taken from Gundimeda et al. (2005b)
3. Water sedimentation data is from Gundimeda et al. (2005b)

4.2.2 Valuation of the stock of Assets

The next step is to develop monetary accounts using the physical accounting framework. In order to monetize the physical accounts valuation is essential. At first sight, valuation of land would seem straightforward; in practice a number of complications arise. The first problem is that although there is a market for land, relatively little land changes hands in any year and so a comprehensive set of prices to cover all land types in all locations is seldom available. Even when prices are recorded, they may be subject to many distortions. Further, some land will never be exchanged on the market but changes hands as it is passed on from one generation to the next. This also includes some of the land for which no market transactions can take place (e.g. wastelands). Sales involving agricultural land may also cover other aspects than the initial purpose of the land. For instance agricultural land with fertile soil and plenty of ground water will fetch a higher price compared to equivalent land without these. Moreover, land sale data would include sales involving conversion of agricultural land to non-agricultural use. Transactions of this nature are likely to be plentiful, and they change the essential basis of the transaction, making it inappropriate for computing cropland sale values (SEEA, 2003).

In such cases where market prices cannot be used, the SEEA suggests using the net present value of future benefits accruing from holding or using the asset as a proxy for market prices. If the value of future benefits did not at least equal the market price, the asset would not be a cost-effective purchase. Thus the net present value should be compatible with market prices. If there are no market prices and it is not possible to calculate the net present value of an asset, then the cost of producing it may be used as a lower bound on its value. In this report we will use this net present value approach to estimate the value of the asset and the changes in assets. Such an approach has been adopted by Gundimeda et al. (2005b). The conceptual framework behind the net present value approach as follows (taken from Gundimeda et al. 2005b).

Let us consider a piece of agricultural land. The land is characterized by several attributes: soil quality, soil texture, soil fertility measured in terms of nutrients, associated water resources etc. With the help of these natural factors and other inputs like seeds, rainfall, fertilizers etc. some output is produced which can be marketed and can have a market value. When the value of man-made inputs are deducted from the output, we get the economic rent or land rent. Variations in these economic rents or land rents are due to differences in the quality of land and inputs mentioned earlier. The economic rent is expected to change every year with the changes in levels of outputs/inputs uses, their prices and the discount rate. Since the resource unit is expected to contribute to the production of one or more resource commodities over a period of time, the asset value for any one land use, say agriculture, will be equal to the present value of the stream of land rent over the economic life of the resource over the relevant planning period. Similarly, the value of the pastureland will be equal to the present value of stream of land rent over the economic life of the resource (Francisco and de Los Angeles (1998). The land rent is obtained by estimating the annual net returns from the use of the resource over time, less a reasonable allowance [15] for profit, which can be represented by:

$$NPV = \sum_{n=1}^{T} \frac{LR_n}{(1+i)^n}$$

where NPV is the net present value of the asset at year n

T is the length of the planning horizon/or economic life of the resource;

i is the discount rate; and LR_n is the land rent in year n

The change in the value of assets (depreciation) is estimated as the change in asset value during the accounting period. On a year-to-year basis, land depreciation is simply measured as the difference between the asset value at the beginning of the year and the asset value at the end of the year.

[15] In this report, I took the net value added from the data published by the Central Statistical Organisation. They usually allow a margin of 10% as return on capital.

If markets work perfectly, net present value based on series of land rent can capture land degradation. This is because the land is being valued for the quality of its inputs especially the soil and the market price of land should capture the quality of soil. However, due to market imperfections, the quality of land may not be reflected. Hence, we try to estimate the value of land degradation using some other methods as discussed below.

4.2.3 Estimating the value of land degradation

If the land is used sustainably, it has an infinite life therefore no adjustment for degradation is required and the whole resource rent can be considered as income. However, as discussed earlier the use of land for agriculture using unsustainable practices would mean degradation of land due to soil erosion in the form of loss of nutrients from the topsoil, movement of soil (changes in soil depth), salinization due to improper irrigation practices, deposition of chemical fertilizers on land etc. In such cases adjustment to income is necessary. Several techniques can be used to estimate the extent of degradation caused which are discussed below.

4.2.3.1 Cost of soil erosion

Soil erosion is a natural process and only when it erodes beyond the tolerable rate, does this have an impact. Under natural conditions, soil lost is largely replenished. However, when the natural rate of replenishment is exceeded by erosion, a physical depreciation of soil resources takes place. In the absence of other forces at play, any loss of soil erosion beyond a tolerable level can be considered as human induced. In this report we are interested in human induced soil erosion and made an assumption that soil erosion impacts the economy in two ways: 1) erosion of topsoil; 2) Sedimentation of waterways. Mainly two approaches have been used in the literature to value the on-site effects of erosion. One approach measures the impact on soil as a resource and second approach is based on effects of erosion on agricultural production. The effects of erosion on soil properties can be examined from the perspective of certain indicators of soil characteristics such as soil nutrient content, soil moisture capacity etc. The effects of erosion on agricultural production can be valued in terms of reductions in crop yields, which can be directly captured through the loss in market value. The most common approach for valuing the loss of soil and soil nutrients is the replacement cost method. This is based on the cost of replacing soil nutrients with artificial fertilizers or the cost of physically returning eroded sediment to the land (the labour costs or the cost of buying fertilizers). The study by Gundimeda et al. (2005b) used replacement cost approach to estimate the value of soil erosion. We borrow the results from the study in this report.

Cost of sedimentation

Siltation or sedimentation in reservoirs is a very serious problem, for it considerably reduces the life of the reservoirs. The life of a reservoir depends on the rate of silt inflow and its dead storage capacity. It has been estimated that many of the reservoirs in India are losing capacity at a rate of 1% - 2% every year (SOER, 2001). In Tamilnadu sedimentation in reservoirs and major tanks is a major problem. The reservoirs have a capacity loss ranging from 3 to 58% (see Table 4.7). In order to estimate the cost of sedimentation two approaches can be used. The first approach is to estimate the value of lost storage capacity and the second way to deal with this approach is to use the maintenance cost method i.e., how much would it cost to remove sediment from water. The study by Gundimeda et al. (2005b) used the cost of removing sediments from reservoirs as an indicative value of the costs imposed by off-site effects of erosion. The same approach has been used in this report. As estimates on the loss in value due to capacity loss are not available, in this report maintenance cost estimate is used.

Cost of degraded lands (Waste lands)

The degradation of land can have an affect on productivity. For example, salinity directly affects the productivity of soils by making the soil unfavorable for good crop growth. Indirectly, it lowers productivity through adverse effects on the availability of nutrients and on the beneficial activities of soil micro flora. Apart from salinity the deposition of heavy metals or industrial effluents and indiscriminate use of agro-chemicals such as fertilizers and pesticides are also responsible for land degradation. The value of such changes though are partly reflected in the current value added in agriculture, it does not give a complete picture of the extent of degradation. Though the soil has degraded, the farmers can respond by adjusting their level of inputs of by changing the cropping patterns, which are less sensitive to erosion etc. Moreover, such lands if left untreated cause more damage to environment than the estimates given by loss in economic productivity approach. Hence, from time to time government invests some expenditure on treating these lands. The study by Gundimeda et al. (2005b) used these expenditures as a proxy to estimate the value of degradation. We borrow the results from that study.

Table 4.7 Sedimentation Rates in Reservoirs in Tamilnadu after 1980

Name of Reservoir/ Tank	Year of Completion	Year in which Capacity survey done	Original Capacity M.Cum	Present Capacity in Million cubic metre%	Capacity Loss in Million cubic meter	Capacity Loss in %	Rate of Siltation
Phase I							
1. Emerald Avalanchi	1960		156.75				
I Survey		1981		145.7	11.05	7.05	0.4
2. Kundah	1960		1.53				
II Survey		1982		0.65	0.89	58.16	2.6
3. Pegumbahalla	1966		0.92				
II Survey		1982		0.63	0.29	31.56	1.9
4. Pillur	1966		44.4				
I Survey		1982		27.33	17.17	38.9	2.4
5. Upper Bhavani	1965		101.15				
I Survey		1985		97.48	3.67	3.63	0.2
6. Krishnagiri	1967		68.2				
II Survey		1983		47.18	21.02	33.81	1.2
7. Sathanur	1957		234.83				
II Survey		1982		207.3	27.53	11.72	0.5
8. Vaigai	1958		194.79				
II Survey		1981		172.439	22.346	11.472	0.5
III Survey		1983		172.28	22.46	11.5	0.5
10. Mettur	1934		2708.75				
II Survey		1983		2157.43	533.33	19.69	0.4
11. Lower Bhavani	1953		932.78				
II Survey		1983		895.03	37.75	4.05	0.1
Phase: II							
1. Amaravathi	1956	1986	117.16	100.32	16.84	14.38	0.5
2. Thirumoorthy	1956	1987	54.8	51.21	3.59	6.55	0.3
3. Willington	1924	1985	71.46	55.322	16.138	22.58	0.4
4. Berijam Tank	1911	1987	2.19	1.8	0.39	17.77	0.2
5. Barur Tank	1919	1986	7.04	6.86	0.18	2.56	0.0
6. Persons Valley	1966	1988	16.422	12.7	3.722	22.665	1.0
7. Kaveripakkam Tank	1902	1989	41.73	37.218	4.512	10.812	0.1
8. Porthimund	1966	1990	60.109	56.4513	3.6579	6.085	2.5
9. Ponniyar	1974	1990	3.388	2.524	0.864	25.5	1.6
11. Veeranam Tank	1923	1991	40.8046	27.744	13.061	3	0.2
12. Upper (Periyar dist)	1968	1991	16.1972	10.6316	6.1479	37.96	1.7
13. Pechiparai	1971	1992	150.27	143.813	6.457	4.3	0.2
14. Manjalar	1967	1992	13.759	10.6316	3.127	22.73	0.9
15. Mukurthy	1938	1993	50.976	34.854	16.385	34.146	0.6

Source: Results furnished by the Institute of Hydraulics and Hydrology, Poondi

4.2.4. CONSTRUCTION OF MONETARY ACCOUNTS

To construct the monetary accounts we have used various approaches mentioned in the section 2. For estimating the value of change in asset accounts we used the net present value method. To compute the net present value we need to estimate the present value of the future net returns from the land, which depends on the cropping patterns, quality of soil, rainfall etc., there has also been a significant change in the cropping pattern in Tamil Nadu, and we feel that this can be captured by taking time-series data on value of output in agriculture. Hence, to estimate the present value of future net returns from agriculture we used the data on value of output in agriculture from 1950-51 to 2000-2001 as used in Gundimeda et al. (2005b). We fitted a linear regression model using time as independent variable and value of output as dependent variable. Using this trend variable (time) we predicted the average future net returns. The net present value of future net returns is obtained using two different discount rates of 4% and 10%.[16] The net present values are taken from Gundimeda et al. (2005b) who assumed the lifespan to be 30 years and discount rate to be 4%.

All the entries in columns 2 to 4 in Table 4.6 (for agricultural and pasture lands) were multiplied with the net present value of land to obtain the monetary estimates give in Table 4.9. The value of inputs and output used in estimation and the net present values used in the report are given in Tables 4.8 and 4.9. For the purpose of estimating the value of depletion, we used a lower bound of 30 years. The estimates will be quite different if different life span is assumed. Moreover, the study did not make any assumption about the value of agricultural land at the end of the life span of 30 years. It may remain in agriculture or converted to other uses, which should be included as well. The opening stocks are multiplied with the net present value of agricultural land in 1992 till 2030 and the values of closing stocks are multiplied with the net present value of agricultural land in 2001. As the difference in values can be because of change in prices used, we have introduced the revaluation term, which takes into account the difference in values between the opening and closing stocks. Similarly, the opening stock of pasture and grazing lands is multiplied with the net present value of the grazing land. Along with agricultural output we get byproducts like straws and stalks and this value is recorded by CSO, so we used this figure as a proxy. We assumed that these by-products come from cereals, pulses and millets, oil seeds, sugar canes and fibres (as assumed by various demand projections on availability of fodder). We extrapolated the value of these by-products per ha from 1950-51 to 2001-2002 into the future. Using the mean contribution of different states in the value of by-products, we estimated the net present value in different states. As these prices reflect the price of dry fodder and not green fodder we used the assumption that 12 tonnes of green fodder is equivalent to 4 tonnes of dry fodder as used by Gundimeda et al. (2005b). Using this assumption the dry fodder values were

[16] We wanted to analyze the impact of using different discount rates.

converted to green fodder values. Here for pasturelands instead of multiplying the opening stocks with the net present value in 1992 and closing stocks with the net present value in 2001, we multiplied the opening and closing stock of pasture and grazing land with the average net present value of these two years (as done in Gundimeda et al. 2005b).

As discussed earlier, changes in quality of soil and land can be captured through tons of soil lost or through the lost output approach. The study by Gundimeda et al. (2005b) attempted to value both. In this report the procedure adopted by the study is given below. In this report we will use the replacement cost of soil erosion. We try to adopt the same values for this report. For the loss in production method we used the net present value of agricultural land as discussed above. In the case of salinity, the NBSSLU (1990) has estimated the loss of production at 25 per cent across soil qualities and crops. In the case of water logging no aggregate estimate for entire state of Tamil Nadu is available, as water logging is mostly confined to command areas. At the micro level the losses due to water logging are estimated at 40 per cent in the case of paddy and 80 per cent in the case of potato (Reddy, 2003). Since Tamil Nadu mostly grows paddy, we took the average of 40 per cent loss in paddy production because of water logging. However, for the purpose of this analysis we have assumed that this lost productivity is already reflected in the present output and hence not considered. For the rest of the degraded land categories like gullies and marshy land, degraded pasture and uplands with or without scrubs, we assumed that entire value is lost.

Another way to estimate the value of degraded land is the maintenance cost approach. Given the scale of land degradation and soil erosion, from time to time the government incurs some expenditure to repair and rehabilitate the degraded land (for example various watershed development programmes).

To estimate the cost of loss of nutrients through soil erosion we used the replacement cost approach. Due to the fact that soil erosion represents a major cause of on-site nutrient loss, the volume of soil loss can be used to estimate the nutrient loss of the study area. We estimated the on-site cost of soil erosion by analysing soil nutrient expressed in per tonne or per cm of soil basis. Due to the important role-played by macronutrients in the soil and because most data are only available for these soil nutrients, the analysis has focused on nitrogen (N), Phosphorous (P) and Potassium (K). The values of available N, P and K are estimated in terms of the equivalent levels of urea (46 0 0), single super phosphate P_2O_5 (0 16 0) and murate of potash or K_2O (0 0 60). Valuation was done using the price of fertilizer per kg of the nutrient published by the Fertilizer Statistics (2004). The nutrients lost were multiplied with the price of fertilizer per kg of the nutrient to get the replacement costs.

To get the monetary estimates for cost of sedimentation the study by Gundimeda et al. (2005b) used maintenance cost approach. The study borrows the same values in the report. An obvious way of restoring reservoir capacity is dredging. However, this is extremely expensive and is normally only viable for small, urban water supply reservoirs where water consumers can afford the cost, and landfill sites are available to take the dredged sediment. A study by Mahmood (1987) cites the cost of dredging at $2-$3 per cubic metre in 1987, around 20 times more than the cost of providing additional storage in a new dam. Restoring the original capacity of major reservoir would require the removal (and transport and dumping) of billions of cubic metres of sediment. We used this value (after adjusting for inflation) as an approximate cost incurred in removing sediments.

Table 4.10 gives the monetary estimates. In the monetary accounts the value of the change in quantity of land is over a 10-year period. Hence, we divided this value by 10. Similarly for the extent of land degradation, as some land already existed in a degraded state before the study period, the study has adjusted for this using the estimate given by SPWD (1984). We deducted the value of land degraded from already existing wasteland from our final table. Soil erosion estimates and sedimentation rates are already expressed on an annual basis; hence they were used without further adjustment.

Table 4.8. Value of inputs and output in agriculture in Tamilnadu in Rs. Lakhs (2002-2003)

Seed	**31419**
Organic Manure	**60872**
Chemical Fertilizers	**79449**
Repair Maintenance	**11243**
Feed of Livestock	**111094**
Irrigation charges	**474**
Agriculture	**19622**
Livestock	**21**
Electricity	**669**
Pesticides	**2792**
Diesel Oil	**13043**
Total value of Input	**330698**
Total Value of Output	**1521059**

Source: Central Statistical Organisation

Table 4.9. Net Present values of agricultural output and fodder used in the study

	Agricultural ouput		**Fodder**	
	4% discount rate	10% discount rate	4% discount rate	10% discount rate
NPV 1992 Till 2032	17058.15	7946.19	1431.50	650.68
NPV 2001 Till 2032	17122.48	8911.49	1469.74	765.45

Source: Gundimeda et al. (2005b)

Table 4.10. Monetary Accounts for Agriculture, Pasture and Waste lands

	Opening stocks	Changes in quantity	Revaluation	Closing stocks
Agricultural Land	89062.11	-7813.81	2574.48	83822.79
Pasture Land	1326.45	97.98	-	1424.43
Productivity losses due to land degradation (20 year period)				
Gullies and Ravines	0.00	-	-	-
Upland with or without scrub	913.5	-	-	-
Water logged and marshy land	0.00	-	-	-
Salt affected land	0.00	-	-	-
Degraded pastures and degraded grazing lands	0.00	-	-	-
Land under shifting cultivation	0	-	-	-
Reclamation cost for 20 years	3485.6	-	-	-
Onsite impact (cost of soil erosion)		-	-	-
Total	9815.20	-	-	-
Of which, Replacement cost per annum of N loss	285.03	-	-	-
P loss	407.97	-	-	-
K loss	9122.2	-	-	-
Off-site impact		-	-	-
Cost of sediment removal per annum (cost of sedimentation)	61.2	-	-	-

Source: computed

4.3 Integration with the national accounts

Our ultimate objective is to adjust the national accounts for the degradation of the environment due to land use for agriculture and grazing, and this is shown in Table 4.11. The estimates in column 6 to 9 of Table 4.11 are derived from the monetary asset accounts (Table 4.10). The total adjustments for depletion and degradation were computed by summing up the depletion and externality costs imposed by agriculture on the environment. The cost of externalities considered includes the replacement cost of soil nutrients, cost of treatment of sediments from waterways and the cost of rehabilitating the degraded land. The reason why we have deducted the cost of rehabilitating the lands is because from time to time Government invests some expenditure to rehabilitate these lands, which should be deducted. Moreover, any land if left untreated causes more harm than good to the environment. Assuming that these lands are treated in course of time, the rent captured in the current year must be adjusted for the costs the sector imposes on the environment. We computed the Environmentally Adjusted State Domestic Product (ESDP) for the state of Tamil nadu after adjusting for subsidies.

From Table 4.11, it can be seen that agriculture does impose significant external costs on the environment in the form of soil erosion and sedimentation of waterways. We have not considered the other impacts on human health due to contamination of waterways with pesticides and fertilizers, which can be quite significant. If NSDP is not adjusted for subsidies, the contribution of agriculture, pasture and wastelands to NSDP of Tamilnadu is lower by 1% due to costs imposed by unsustainable land use practices. However, if we deduct subsidies, the costs are quite high, ranging to as much as 24%. The results also indicate how much should be set aside in order to maintain the environmental capital in tact. Our results thus should be viewed with care because of the limitations of available data. Data required for agricultural accounting is site-specific. It depends on local conditions, topography, crop management factors, etc. However, in line with our stated objectives, we used aggregate estimates available from various secondary sources. Site-specific estimates can be used at a more disaggregated level of accounts (such as the state and its districts) at a later stage.

Table 4.11. Adjustments in the National Accounts for 2002/2003 (Rs Million)

GSDP 2002-2003	1537287
NSDP current prices 2002-2003	1367809
Changes in quantity of Land	-429.32
Cost of Land reclamation	17.15
Replacement cost of soil nutrients	9815.2
Cost of sedimentation	61.16
Total adjustment for depletion and degradation	-10278.8
Environment adjusted state domestic product	1357530.2
ESDP/NSDP	0.992
Value added by agriculture	152105.9
Agricultural subsidies	12220.2
Value added by agriculture adjusted for subsidies	139885.7
ESDP after adjusting for agricultural subsidies	1345310.0
Depletion and degradation as per cent of ESDP (adjusted for subsidies)	0.76

ANNEXURE I

Standard definition of various categories of land use adopted in land utilization statistics (notes for Table 1)

Forests	Forests include all lands classed as forest under any legal enactment dealing with forests or administered as forests, whether state owned or private, & whether wooded or maintained as potential forest land. The area of crops raised in the forests & grazing lands or the area open for grazing within the forests should remain included under the forest area.
Land under non-agriculture use	This category included all lands occupied by buildings, roads & railways or under water, e.g. rivers & canals, & other lands put to uses other than agriculture.
Barren and unculturable land	This category covers all barren & unculturable lands, including mountains, deserts, etc. which cannot be brought under cultivation, except at a high cost, is classed as unculturable, whether such land is in isolated blocks or within cultivated holdings.
Permanent pastures and other grazing land	This category covers all grazing lands whether they are permanent pastures or meadows or not. Village commons and grazing lands are included under this category.
Miscellaneous tree crops and groves	Under this class is included all cultivable land which is not included under the net area sown, but is put to some agricultural use. Lands under Casuarina trees, thatching grass, bamboo bushes & other groves for fuel, etc. which are not included under 'orchards' are classed under this category.
Culturable wasteland	This category includes all lands available for cultivation, whether taken up for cultivation or not, taken up for cultivation once but not cultivated during the current years and the last 5 years or more in succession. Such lands may be either fallow or covered with shrubs & jungles, which are not put to any use. They may be assessed or unassessed and may lie in isolated blocks or within cultivated holdings. Land once cultivated, but not cultivated for 5 years in succession, shall also be included in this category after 5 years.
Current fallows	This class comprises cropped areas, which are kept fallow during the current years only. For example, if any seedling area is not cropped again in the same year, it may be treated as current fallow.
Other fallow land	This category includes all lands, which were taken up for cultivation but are temporarily out of cultivation for a period of not less than 1 year & not more than 5 years. The reason for keeping such lands fallow maybe one of the following: (a) Poverty of the cultivators (b) Inadequate supply of water (c) Silting of canals & rivers, and (d) Un-remunerative nature of farming. e) Unfavourable climate etc.
Net area sown	This term denotes the net area sown under crops and orchards, counting areas sown more than once in the same year only once.

Source: Wastelands atlas of India 2000, Dept. of Land Resources, Ministry of Rural Development, Government of India

5. Accounting for Water Resources

Water resources are defined as the water found in fresh and brackish surface water and ground water bodies within the national territory. In the case of surface water, the volume in artificial reservoirs and watercourses is included in addition to that in natural water bodies. The water of the oceans and open seas is excluded because the volumes involved are so enormous as to make any stock measure meaningless. Further, any extraction for human use has no measurable impact on them. In the 1993 SNA surface water is not recognized as an account explicitly. It is only mentioned in the SNA asset classification in association with land areas that are within the asset boundary. Surface water can be brought into the economic use for a variety of ways. The SEEA therefore recognizes surface water resources as an environmental asset because they provide use benefits. The 1993 SNA recognizes only groundwater resources as a distinct asset and then only "aquifers and other groundwater resources to the extent that scarcity leads to the enforcement of ownership and/or use rights, market valuation and some measures of economic control." The SEEA extends this to include all groundwater resources on the basis that those that do not provide current use benefits may one day do so, and therefore, provide option and bequest benefits. The ecological functions of water are included in the SEEA under aquatic ecosystems. This environmental accounting for water comprises both of asset accounts as well as flow accounts. This report tries to operationalise the asset accounts for water. The asset accounts can be of two types: the volume accounts and the quality accounts. In the next two sections, I try to suggest a framework for constructing asset accounts for water both quantity and quality and then look at the data availability to operationalise this framework.

5.1 Asset accounts for water

Asset accounts for water describe how the stocks of water at the beginning of the accounting period are affected by flows of water between the environment and the economy and transfers of water internal to the hydrological system to reach the stocks of water at the end of the accounting period. Before embarking on the compilation of asset accounts for water, the definition of water stock has to be clarified. For groundwater, reservoirs and lakes it is conceptually simple to measure stocks. For rivers, the stock of water is not well defined due to the "flowing" nature of the resource. Here to maintain consistency with the other water resources, the stock of water in a river is measured as the volume of riverbed. However, the volume of riverbed is not always a good measure of water stocks, especially for Ephermal Rivers. An alternative solution is to consider annual runoff into the river or the mean annual runoff in a country subject to a very large annual variation.

Annual runoff is the total volume of water that flows during a year, usually referring to the outflow of a drainage area or river basin. For perennial rivers, runoff is measured at the lowest point downstream.

Hence, it includes all flows, which have taken place upstream. For rivers crossing national borders, runoff up to the point of entry into the country should be deducted. Mean annual runoff is defined as the average net annual rainfall under natural conditions. The result depends on the runoff regimes for each river basin. Using average flows over a period of time as a proxy for stock figures presents problems in the asset accounts, as some of the flows in the table may be already included depending on where the river flow is measured. In such a case, the flows in the asset account should be modified accordingly to avoid double counting. Table 1.5 represents an asset account for surface water and ground water resources. The classification of water resources does not include water in soil and vegetation, permanent snowfields and ice. In this case, the accounts measure the precipitation, which reaches surface and ground water. The runoff to surface water and infiltration to ground water are therefore net of evapotranspiration.

Table 5.1 An asset account for inland water

	Surface water				
	Reservoirs	Lakes	Rivers	Ground water	Total
Opening stocks					
Abstraction (-)					
Residuals (+)					
Net precipitation (+) Inflows (+) Net natural transfers (+/-) Evaporation from water bodes (-)					
Outflows					
Other Volume Changes					
Closing stocks					

The opening and closing stocks represents the quantity of water, in cubic metres, at the beginning and end of the accounting period. The changes in stocks during the accounting period can be caused by human activities (abstraction and return of water to the environment) and by natural process (precipitation, evapotranspiration, natural inflows and outflows to other rivers, etc.) The detailed description of the table entries is as follows:

Abstraction shows the total volume of inland water abstracted in a year

Residuals represent the total volume of water in the accounting period returned to the environment.

Precipitation consists of all precipitation. When the category “water in soil” is not included in the tables the figures for precipitation are net of evapotranspiration. It represents the part of the total annual precipitation that reaches the lakes, rivers, reservoirs and groundwater whether directly, via runoff or by infiltration.

Inflows represent the total volume of water in the accounting period that enters the territory of reference. For a river that enters the territory of reference, the inflow is the total quantity at its entry point.

Net Natural transfers for a water resource are defined as the difference between the inflows to one type of water resource from all the others and the outflows from the same water resource to all the others.

Evapotranspiration is the total volume of evapotranspiration from the ground, wetlands and natural water bodies and transpiration of plants where the soil is at its natural water content. This is a hydrological concept. It excludes the evapotranspiration generated by all human intervention except for non-irrigated agriculture and forestry.

Outflows represent the volume of water that leaves the territory of reference during the accounting period. This flow could be disaggregated depending whether the flow is to other territories or to the sea.

Other changes in volume include all the changes in the stocks of water that are not specified elsewhere in the table. The item can either be estimated or calculated directly.

5.2 Water Quality Accounts

The use to which water can be put depends crucially on its quality. For example, water used for hydroelectric power generation, industrial purposes and transportation does not require high standards of purity, whereas other uses (drinking, recreation, habitat for aquatic organisms etc) rely on higher levels of purity. Once quality classes are defined, water quality account can be constructed following the same general structure as an asset account in physical terms with quality as simply another dimension. The accounts show the opening and closing stocks together with the changes in stocks during the accounting period for quality class. Once quality classes are defined, water quality accounts can be constructed following the same general structure as an asset account in physical terms with quality as simply another dimension. The accounts show the opening and closing stocks together with the changes in stocks during the accounting period for each quality class (see Table 1.6). Quality classes can be defined in various ways. Quality classes of surface waters can be defined according to the level of pollution with organic matter such as BOD (Biochemical oxygen demand), COD (Chemical oxygen demand) or by measures such as ammonium ion concentration.

Table 5.2 Quality accounts

	Quality classes				
	Q1	Q2	Q3	Q4	Q5
Opening stocks					
Changes in stocks					
Closing stocks					

The general structure of quality accounts is simple conceptually. However, it presents numerous problems of measurement. Temporal and spatial considerations play important roles in water quality and should be taken into account when compiling quality accounts, especially if the accounts are used for water management. The quality of a river, for example, might increase enormously during particular weather conditions, and decrease rapidly when the conditions change. Periodic variation, such as time of the day, season, year, are complemented by sporadic changes in quality due, for example, to a sudden catastrophe. In addition, a long river may contain water of different quality at various points, with quality often being high at the source of the river and low at the mouth. Another issue relates to the measurement of stocks of water of a certain quality. Water quality is measured at a single point and it is difficult to aggregate such measurements to represent large regions such as big lakes, rivers and even drainage regions. This problem is particularly difficult for rivers due to the flowing nature of the water.

5.2. Profile of Water Resources in Tamilnadu

The state of Tamilnadu lies in the southern tip of India covering 4% of geographical area and 7% population of the Country. Average rainfall is about 925 mm. There are 33 basins in Tamilnadu including minor river basins. The nearer minor basins have been grouped together into 17 major river basins and the details of river basins that are grouped into a major basin is furnished below.

TABLE 5.3. RIVER BASINS OF TAMILNADU

Sl. No.	Major River Basin	Name of River Basin
01	Chennai River Basin	1) Araniyar 2) Kusaithalaiyar 3) Cooum 4) Adayar
02	Palar	5) Palar
03	Varahanandi	6) Ongur 7) Varahanandi
04	Ponniyar	8) Malattar 9) Ponniyar 10) Gadilam
05	Paravanar	11). Vellar
06	Vellar	
07	Cauvery	12) Cauvery
08	Agniyar	13) Agniyar 14) Ambuliyar 15) Vellar
09	Pambar & Kottakariyar	16) Koluvanar 17) Pambar 18) Mamimukthar 19) Kottakaraiyar
10	Vaigai	20) Vaigai
11	Gundur	21) Uthirakosmangaiyar 22) Gundur 23) Vembar
12	Vaippar	24) Vaipar
13	Kallar	25) Kallar 26) Korampallam Aru
14	Thamaraparani	27) Thambarapani
15	Nambiyar	28) Karmaniar 29) Nambiyar 30) Hanummandhi
16	Kodaiyar	31) Palayar 32) Valliyar 33) Kodaiyar
17	P.A.P	West flowing river

Source: State Frame Work Water Resources Plan of Tamilnadu – Draft Final Report, IWS-Chennai.

BASIN-WISE INFORMATION

Basin-wise information about basin area, basin area occupying adjoining State and District wise area are furnished in the following table.

Table 5.4. Basin wise information of annual surface and ground water potential in various river Basins in TamilNadu

River Basin	Area in hectares	State-wise Area	District-wise Area in hectares	Annual Surface water Potential in MCM	Ground water Potential in MCM
1. Chennai	7292	Tamilnadu & AP	Chennai (174), Chengalpet and Tiruvallur (4275)	906	1120,22
2. Palar	18300	Tamilnadu-(10910) Karnataka-3123, AP-4267	Vellore-4710, Tiruvannamalai-4013, Kancgheepuram-2187	1758	2610,32
3. Varahanandi	4357	Tamilnadu-4214, Pondichery-143	Chengalput-770, Tiruvannamalai-306, Cuddalore-3138	416,09	1482,07
4. Ponniyar	11257	Tamilnadu	Dharmapuri-6744.03, Vellore& Tiruvannamalai-1315.37, Cuddalore & Villupuram-3197.66	1310	1560
5. Paravanar	760	Tamilnadu	Cuddalore	104,3	225,5
6. Vellar	7659	Tamilnadu	Dharmapuri-1478, Salem-2439, Tiruchy- 1658, Villupuram-1855, Cuddalore-1638	1071	1344
7. Agniyar	4566	Tamilnadu	Thanjavur, Tiruchy, Pudukottai	1084	920
8. Pambar & Kottakariyar	5847	Tamilnadu	Dindigul-1478, Tiruchi& Karur-44, Pudukottai-809, Karaikudi-2989, Madurai-279, Ramanathapuram-1248	653	976
9. Vaigai	7031	Tamilnadu	Madurai-3913, Dindigul-1578, Ramnad-770, Karaikudi-761	1579	993
10. Gundur	5647	Tamilnadu	Ramnad-2131, Thoothukudi-285, Viruthunagar-1339, Karaikudi-209, Madurai-1383	567,52	766
11. Vaipar	5423	Tamilnadu	Viruthunagar-3579, Madurai-380, Tirunelveli-271, Thoothukudi-1193	613,952	1168,88
12. Kallar	1878,8	Tamilnadu	Thoothukudi	141,93	69,58
13. Thamaraparani	5969	Tamilnadu	Tirunelveli-5317, Thoothukudi-652	1375	744
14. Nambiyar	2084	Tamilnadu	Thoothukudi-520, Tirunelveli-1464, Kaniyakumari-100	203,87	274,74
15. Kodaiyar	1533	Tamilnadu	Kanniyakumari	925	342,1
16. Prambikulam Aliyar	3462	Tamilnadu	Coimbotore-2829, Erode-633	416	751
Total	**93065,8**			**13124,662**	**15347,41**

TOTAL SURFACE WATER POTENTIAL

The total surface water potential of river basins of Tamilnadu except Cauvery basin is 13,117 MCM (448 TMC).

Table 5.5. Surface Water Potential of River Basins (except Cauvery River Basin)

Sl. No.	River Basin	Methodology	Surface Water Potential 75% dependability MCM
1	Chennai	0-15 Run off co-efficient	906
2	Palar	Run off co-efficient	1758
3	Varahanandi	0-15 Run off co-efficient	416
4	Ponniyar	0-15 Run off co-efficient	1310
5	Vellar	0-15 Run off co-efficient	1071
6	Paravanar	0-15 Run off co-efficient	144
7	Agniyar	0-15 Run off co-efficient	1084
8	Pambar & Kottakariyar	0-15 Run off co-efficient	653
9	Vaigar	0-15 Run off co-efficient	1579
10	Gundur	0-15 Run off co-efficient	568
11	Vaippar	Run off co-efficient	616
12	Kallar	0-15 Run off co-efficient	142
13	Tamrapani	Run off co-efficient	1325
14	Nambiyar	Run off co-efficient	204
15	Kodaiyar	Actual flow & Run off co-efficient method	925
16	P.A.P	Actual flow measurement	416
	Total		**13117**

Source: State Frame Work Water Resources Plan of Tamilnadu – Draft Final Report, IWS-Chennai.

More than 95% of the surface water and 60% of the ground water have been put to use. In Tamilnadu the surface water resources are fully harnessed by impounding the available water in 61 major reservoirs and also in 39,202 small and big tanks. As per recent estimates, 60% of available ground water resources are now used, and the remaining resources are available in selected pockets of coastal sedimentary tracts in the eastern part. The total surface water potential of all the river basins, excluding Cauvery, is estimated to be in the order of 13,117 Mcm and the total ground water potential of all river basins, excluding Cauvery is worked out 15,346 Mcm. Thus an estimated total water resources potential of all river basins, excluding Cauvery basin is estimated in the order of 28,463 Mcm. Total water demand as on 1999 for domestic, irrigation, industrial, livestock, Power etc, except Cauvery basin area estimated as 31,164 MCM. It is to be seen that water demand is in excess of water available.

The water is abstracted for domestic, industrial and agricultural uses. While constructing the asset accounts for water, the domestic water requirement for the urban and rural area have been assumed at the rate of 90 lpcd for urban and 40lpcd for the rural population. Since time immemorial, the largest users of all the available water resources are the agriculturists through minor irrigation sources. The limited available surface water supplies, at present, are completely utilised and farming has to depend largely on ground water resources for supplementing the irrigation system in the command areas and to a lesser extent in non-ayacut areas in low flow season. Irrigation is extremely water intensive and most of the irrigation systems are grossly inefficient in Tamilnadu. Irrigation is practiced both through system and non-system tanks in the command areas using Surface Water as the main source supplemented with ground water whenever demanded, whereas in the non-ayacut areas cultivation is carried out during rainy seasons raising only single crop variety using to certain extent rain water and to large extent water abstracted from wells. The cropping pattern of all basins indicates that Paddy is the general predominant crop followed by Sugarcane, Groundnut, Ragi, Cotton, Cholam, Cumbu, Oil seeds, etc. To compute the water demand (present status and future demand) for agriculture crops water requirement, a study by the State Framework Water Resource Plan of Tamilnadu (2000) computed the water requirement for crops based on the crop statistics. Further while estimating the surface water requirement, the study assumed that the efficiency of the irrigation system is assumed as 40% and that of the wells as 75%. While computing the industrial demand for water, the study has estimated the industrial water sector demand based on the product, quantity manufactures, its water consumption as furnished by industries etc. Based on this the total water demanded by major users for the year 1999 is given in Table 5.6.

Surplus Flow to Sea

In most part of the river basins, flood occurs during monsoon seasons for short duration. As a result, considerable quantity of water is flowing into sea. In most of the river basins, the details of surplus flow into the sea are not available. The Statement showing the surplus flow to sea in each river basin of Tamilnadu (except Cauvery basin) is given in Table 5.6.

Table 5.6. Surplus flow into Sea in each River Basin (except Cauvery River Basin)

River Basin	Data available			Surplus to sea MCM average
	From	To	No. of Years	
1. Chennai	1987	1993		274
2. Palar	79-80	89-90	11	204
3. Varahanandi	1990	1995	6	389
4. Ponniyar	72-73	85-86	14	201
5. Vellar				523
6. Paravanar	68-69	94-95	27	340
7. Agniyar				
a. Agniyar sub -basin	88-93		6	61
b. Ambuliyar sub-basin	89-93		5	71
c. South Vellore sub-basin	88-93		6	26
Total				**158**
8. Pambar & Kottakariyar	93-94		1	42
9. Vaigar				
a. Ramnad Big Tank	77-78	94-95	18	54
b. Periyar Dam*	77-78	94-95	19	27
10. Gundur	1966	1986	21	27
11. Vaipar	75-76	93-94	17	150
12. Kallar	1953	1953	37	15
13. Thamaraparani	1971	1994	24	364
14. Nambiyar	1991	1993	3	149
15. Kodaiyar	79-80	92-93	12	412
16. Prambikulam Aliyar				3

5.3. Operationalising Asset accounts for water

The surface water can be through river basins, reservoirs and tanks. The detailed opening stock is not available for all the three types. Table 5.7 gives asset accounts for ground water and surface water. The opening stock comprises of the stock of water present at the beginning of 1999. The stock reduces mainly because of abstractions from domestic, industrial, livestock, hydropower and environmental needs. Based on the information discussed in the earlier section the water requirement by different users is indicated in table. However, the other data required for constructing the asset accounts is not available. We have the information on evaporation, precipitation and run-off and this is the net opening stock we have used in this report. Outflows can be transfer to seas. This data is available but not for all the river basins.

Table 5.7. Physical Asset accounts for water

	Total surface water	**Ground water**	**Total**
Opening stocks	13117	15346	28463
Abstraction (-)			
Domestic			1001.51
Industrial			635.99
Livestock			387.04
Hydro power			60.29
Environmental needs			28.00
Total			**31192**
Residuals (+)			
Net precipitation (+) Inflows (+) Net natural transfers (+/-) Evaporation from water bodes (-)			
Outflows			3332
Other Volume Changes			
Closing stocks			

It can be seen that the water asset accounts are negative. This is because some of the demand is met by transfers from other rivers.

Water Quality accounts

Constructing water quality accounts is difficult because water quality depends on the location (whether upstream or downstream). The water quality of the surface and ground water can be measured by Electrical Conductivity – salinity, Biological oxygen demand, Chemical oxygen demand, PH etc which are site specific. Table 5.8 and 5.9 gives the water quality accounts for the years 2006 and 2003 for the River Cauvery because this is one of the largest rivers in Tamil nadu. Table 5.10 gives the use based classification of various rivers in India. Some of the parameters are above or below the standards in the tables. We can see that the number of violations are different for the two years. However, we do not know if the conditions at which the two measurements were takes are same or not (i.e. whether it is in the same month or whether there has been any rainfall during the previous one week etc. because rain scavenges the pollution). So we donot make any attempt to interpret the data here.

Table 5.8 Water quality of River Cauvery in Tamilnadu for the year 2006

	MEAN temperature	MEAN DO (mg/l)	MEAN pH	MEAN Conductivity (µmhos /cm))	MEAN (BOD) mg/l	MEAN Nitrate (mg/l)	MEAN Nitrite (mg/l)	MEAN Faecal Coliform (mpn/100 ml)	MEAN total coliform (mpn/100 ml)
CAUVERY AT METTUR	30	5.7*	7.91	500	2.3*	0.16	0.32	170	380
BHAVANI AT BHAVANI	30	7.3	7.84	512	2.3*	0.43	0.35	553	1533
CAUVERY AT PALLIPPALAYAM	27	5.6*	7.74	626	2.3*	0.27	0.30	293	628
CAUVERY AT ERODE NEAR CHIRAPALAYAM	30	5.8*	7.81	590	2.8*	0.28	0.46	535	1400
CAUVERY AT VELORE NEAR KATTIPALAYAM	29	7.7	8.08	830	2.3*	0.14	0.24	383	838
CAUVERY AT MOHANUR NEAR PATTAIPALAYAM	29	7.9	7.97	849	2.5*	0.14	0.22	495	1075
CAUVERY AT THIRUMUKKUDAL-CONFL. PT.OF R. AMRAVATI		8.0	8.10	675	2.0	0.13	0.20	220	500
CAUVERY AT MUSIRI		7.8	8.05	783	2.0	0.10	0.25	210	420
CAUVERY AT TIRUCHIRAPPALLI U/S		7.6	8.16	628	2.0	0.34	0.15	170	330
CAUVERY AT TIRUCHIRAPPALLI D/S		8.0	8.28	621	2.0	0.20	0.12	210	500
CAUVERY AT TRICHY,GRAND ANAICUT		6.5	7.82	1039	4.0*	0.25	0.11	365	830
CAUVERY AT THANJAVUR, TAMILNADU	28	8.2	7.87	797	2.0	0.15	0.30	330	2800
CAUVERY AT COLEROON, TAMILNADU	28	8.0	7.71	787	2.0	0.24	0.20	340	833
CAUVERY AT PITCHAVARAM, TAMILNADU	28	5.8*	7.28	1142	2.0	0.49	0.40	610	1523
CAUVERY AT 1KM. D/S OF BHAVANI RIVER CONFL., TAMILNADU	30	6.7	7.84	514	2.3*	0.37	0.24	480	1173

Source: CPCB

* indicates violation of parameters for category A use (i.e drinking water without conventional treatment but disinfection)

Table 5.9 Water quality of River Cauvery in Tamilnadu for the year 2003

	Temperature	pH	Conductivity	D.O (mg/l)	BOD (mg/l)	Feacal coliform (MPN/ 100 ml)	Total coliform (MPN/100 ml)	Nitrite (mg/l)	Nitrate (mg/l)	COD
Cauvery at Mettur	31	8.0	623	7.2	2.0	131	550	0.054	-	31.0
Bhavani at Bhavani	30	8.1	382	6.7	2.2	240	1254	0.125	-	24.0
Cauvery at Pallippalayam	29	8.0	860	6.3	3.2*	932	4308	0.082	-	31.0
Cauvery at Erode near Chirapalayam	30	8.1					6432	0.169	-	-
Cauvery at velore near kattipalayam	29	8.1					942	0.075	0.222	24.0
Cauvery at Mohanur near Pattaipalayam	29	8.1	752	7.2	2.3*	172	762	0.072	0.180	56.0
Cauvery at Thirumukkudal-confl. Pt.of r. Amravati	30	8.0	590	7.5	2.0	188	615	0.104	-	39.0
Cauvery at Musiri	-	8.2	424	8.3	2.0	190	335	0.047	-	-
Cauvery at Tiruchirappalli u/s	-	8.1	426	8.2	2.0	320	870	0.162	-	-
Cauvery at Tiruchirappalli d/s	-	7.4	587	6.3	3.5*	335	1000	0.341	-	-
Cauvery at Trichy, grand anaicut	-	8.3	613	7.1	2.5*	113	500	0.186	-	-
Cauvery at Coleroon	30	7.8	13990	7.5	2.0	61	616	0.024	-	338.0
Cauvery at Pitchavaram	30	7.8	14122	6.8	2.1*	50	240	0.028	-	519.0
Bhavani at Pathirakaliamman koil	29	7.3	166	7.6	2.0	343	1835	0.031	-	16.0
Bhavani at Sirumugai	30	7.3	144	7.7	2.0	514	2303	0.025	-	24.0
Bhavani at Bhavani Sagar	30	7.9	265	6.7	2.1*	175	561	0.071	-	16.0
Cauvery at 1km. D/s of Bhavani river confl.	30	8.1	467	6.4	2.6*	206	860	0.179	-	40.0
Amravati at 1km d/s from eff.dis. Pt. At Madhuthukkulam	28	7.9	155	7.9	2.3*	880	2812	0.034	-	-

Source: CPCB

* indicates violation of parameters for category A use (i.e drinking water without conventional treatment but disinfection)

Table 5. 10. Use based classification of surface water in India

Drinking Water Source without conventional treatment but after disinfection	A	1. Total Coliforms Organism MPN/100ml shall be 50 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 6mg/l or more 4. Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
Outdoor bathing (Organised)	B	1. Total Coliforms Organism MPN/100ml shall be 500 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 5mg/l or more 4. Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Drinking water source after conventional treatment and disinfection	C	1. Total Coliforms Organism MPN/100ml shall be 5000 or less 2. pH between 6 to 9 3. Dissolved Oxygen 4mg/l or more 4. Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Propagation of Wild life and Fisheries	D	1. pH between 6.5 to 8.5 2. Dissolved Oxygen 4mg/l or more 3. Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	1. pH between 6.0 to 8.5 2. Electrical Conductivity at 25°C micro mhos/cm Max.2250 3. Sodium absorption Ratio Max. 26 4. Boron Max. 2mg

5.4 Monetary accounts

There are two main ways in which water can be valued. The first and uncontroversial measure is that of the direct market price. The second is the appropriation method. In addition, other methods are sometimes used.

Market Prices

Market prices can be used to value water resources. Sometimes the charges are not accurate as the charging is still made on the basis of a flat fee per dwelling; more often there is a move to charge by volume consumed. Even when the charges are levied per litre consumed the rates charged may vary considerably from one kind of user to another. For example, for agricultural users, water is supplied at very advantageous rates leading to excessive overuse with consequent shortages for other consumers. For the purpose of sound management of the resource, monetary accounts should be drawn up to show the different classes of consumer linked to the different rates charged.

Appropriation method

Another form of pricing of growing application is the issuing of water rights. These may offer a short term rental of a water source or perpetual water rights. Short-tem rentals grant rights for a limited period of time, say for one irrigation cycle or a season. The prices observed in this situation are short run and may often reflect other factors in addition to the marginal value of water. The prices paid for the rights can be taken as the value of the water available in the period covered by the rights and a value for the total stock of water estimated using net present value techniques applied to future rights issues. Prices paid for perpetual water rights represent an immediate estimate of the stock of water to which the rights give access without the need for net present value calculations. There is however an element of speculation involved in determining these prices and with an underdeveloped market in such rights, care should be used in using these prices.

Other methods

In principle, it would be possible to calculate a resource rent for water used for irrigation by looking at the rent for similar unirrigated land and attributing the increase for the irrigated land to the water used. In practice, however, it is unlikely that the same crop will be grown extensively on near-identical land with and without irrigation so this is not likely to be a very practical means of valuation. The valuation technique of last resort, which is least satisfactory from a theoretical point of view but perhaps most common in practice, is to set the value of water equal to the cost of making it available. This method is not quite satisfactory of course, as this confuses the price of water with the cost of water. However, as the water is a scarce resource, there is a marginal cost imposed on the user. No estimates exist to exactly value the water. One study by Gundimeda and Kathuria (2005) exists for estimating the total value of water to domestic consumers. Apart from this no other study exists and hence no attempt has been made to value water resources as the value of water varies from user to user.

Chapter 6. Conclusions

The final objective of this exercise is to integrate the estimates obtained in the earlier chapters together with the national accounts. By such integration, the threats to natural resources such as land and water that originate from various sectors in the economy can be identified. In the conventional national accounts only the depletion of the manmade assets is included in net state domestic product. In the current system of national accounts, when forests are converted to non-forest purposes, only the costs of extraction are recorded in the national accounts and the changes in assets are recorded in the category other volume changes which do not have any impact on GDP. As we discussed earlier, when forests are logged (above the mean annual increments) or converted to nonforest purposes, potential values of the forests are lost and need to be accounted for rather than just accounting for the income from harvesting. Similarly, when land is degraded due to over use, any expenditures incurred in improvement in land are recorded as fixed capital formation. Two main adjustments are required in SEEA. First adjustment involves that the net state domestic product need to be adjusted for the use of natural assets in the production process (i.e. the depletion). The second adjustment is to replace the net capital formation in SNA with net accumulation. Our main focus is on the income related adjustment in this paper, i.e. we used the following formula to compute the environment adjusted state domestic product (ESDP)

$ESDP = NSDP + (A_{np.ec} + A_{np.env})$

The second term captures the net effects of addition and depletion/degradation of natural assets (non produced economic assets (np.ec) and non produced environmental assets (np.env)[17]) that are transferred to economic uses (this is equal to changes due to economic activities + other accumulations but does not include other volume changes).

Thus instead of considering only the Net state domestic product (obtained after the considering the depreciation of manmade assets), the environment adjusted state domestic product (ESDP) need to be considered for policy which takes care of the depletion of natural resources due to various economic activities. For an economy to be on sustainable path the ratio of ESDP to NSDP should be greater than one.

However, to enable such an integration core land cover and land use accounts discussed in chapter 2 should be available for all the years. As the data is not available for the same years for different land cover classes, we could not integrate all the estimates together. But we have illustrated how to

[17] Non-produced assets are those assets over which ownership rights are enforced by institutional units individually or collectively and capable of brining economic benefits to their owners. For example, this includes forests under concessionaires. Non-produced environmental assets are those assets where no effective ownership right is enforced but economic benefits or ecological benefits may be derived from their use. For example, forests in wilderness.

integrate this into the national accounts individually for forests, agricultural, pasture land and wasteland but could not illustrate for water resources due to lack of uniform data for all the years. Ideally the adjustments should be sum across all land cover classes. Forests, pasture or grasslands, agricultural, wastelands, built up areas and land under water bodies are all different subcategories of landcover. As land resources are fixed and cannot be created nor destroyed, land can only change from one use to another. For example, land earlier under forests can be converted to agriculture or agricultural lands can be converted to built up areas. In such cases, the value of such changes will be reflected if proper adjustments are made. If forest lands are converted to agriculture, this is recorded as transfer to nonforest purposes, thereby decreasing the forest cover and decreasing the asset value of forests. However, this is reflected as increases in agricultural land resulting in increase in the asset value of forests. Similarly if agricultural land is converted to builtup areas, the asset value decreased in agricultural sector but the asset value of builtup area increases. The total effect can be positive or negative depending on whether the asset value has increased or decreased as a result of this conversion. Our study did not construct accounts for builtup areas as they are already recorded in the accounts under gross capital formation (under buildings).

The study would like to end with positive note that if more information is available, definitely it is possible to do it. Some of the limitations of the study due to want of data need to be mentioned for future data collection.

- The recorded volume of timber harvested/logged was derived from the production statistics of timber and fuel wood obtained from the CSO for the year 2002-2003. However the volume harvested for timber and fuel wood is highly debated as the estimated consumed volume exceeds the recorded produced volume. A considerable amount of timber and fuel wood goes unrecorded due to illegal felling of trees. In order to account for unrecorded production, the CSO uses an estimate of 10% of the total recorded production of industrial round wood as the value of unrecorded production of industrial round wood (which is an approximate estimate). For fuel wood, the CSO estimates the unrecorded removals of fuelwood by superimposing the trend of fuel wood consumption observed from the NSSO consumption surveys for the year 1983-84 on the estimates for 1980-81 prepared on the basis of recorded production (See CSO, 1989). Despite accounting for unrecorded production based on the norms set by CSO, on tallying the volume accounts at the end we found that for most of the states some growing stock is still missing. So we accounted for some of this difference in the growing stock as unrecorded removal, which could not be tracked by the forest department. In this paper, we made an assumption that if it is recorded in the national accounts, it is no longer unrecorded production and only the differences in the growing stock (not tallied) can be treated as unrecorded production.

- Damage due to logging is assumed to be 10% of the volume of timber logged from both recorded and unrecorded production We assumed that some of the damaged timber leaves the forested land because deadwood is collected for use as fuel. The remaining timber is left on-site but is assumed that it is an economic loss.
- In India forests are encroached every year illegally. The volume of timber lost due to shifting cultivation and forest encroachment is obtained by multiplying the area subject to this disturbance with the growing stock per hectare in open forests. However, the area statistics are not accurate.
- The statistics on afforestation reported at the national level do not indicate various species planted, the survival rate of these plantings, how much area actually ends up forested and the growing stock per ha in these afforested areas. Such effort is being made by the FSI for some agro-forestry areas but is not yet complete. So the study estimates the volume additions due to afforestation by multiplying the area afforested with the mean annual increment per sq. km and assume that the same conditions prevail at the existing sites.
- The volume lost due to grazing is derived by multiplying naturally regenerated volume and the afforested volume with the percentage of area subject to heavy grazing. However, no carbon loss is assumed from grazing because the carbon increases due to regeneration (if any) on the grazed land is assumed to be offset by loss in carbon due to surface fires and grazing. More information is required on this front.
- Other accumulations due to natural processes consist of the natural growth (mean annual increment) and natural regeneration. The mean annual increment of different species is taken from the statistics published by the FSI (1995b). This volume estimate is converted to units of carbon using the same method as discussed earlier. The area regenerated (naturally and artificially) is obtained from ICFRE (2000), but only in some states. The volume added is computed by multiplying the area regenerated with the mean annual increment per hectare of different species.[18] However, accurate information on the volume regenerated is required.
- The volume reduction due to transfer of land for non-forest purposes is derived by multiplying the area transferred with the growing stock per hectare. Here we assume that there is some standing timber left on the forestland before the land is converted to nonforest purposes. This timber may be used in various wood products from which the carbon will be released depending on the use to which it is put to.
- The area subject to forest fire is given by ICFRE (2000). The volume of forest stock affected by forest fire is derived by multiplying the naturally regenerated volume and the afforested

[18] As a result of frequent fires and heavy grazing only 18.3% of the total forest area has regeneration potential of important species (FSI, 1995a).

volume with the percentage area affected by the forest fire.[19] Haripriya (2003) estimated that when the forest is affected by fires, only 20% of the stem biomass remains, 50% is burnt and the carbon transferred to the soils (immediate and releases that eventually occur in future as a result of fires today) and 30% is released into the atmosphere.

- The latest statistics available about insect induced mortality at the time of this analysis are estimates from Indian Forest Statistics (various years between 1947 to 1972) for various states. These statistics reveal that the average volume rendered unusable annually due to attack of insects/pests is around 0.031% for broad-leaved species and 0.005% for coniferous species. From this the average volume lost due to insects and pests has been derived for the years 1947-70[20] and the same proportion has been used for the study period. The volume estimates are converted to carbon estimates as discussed before.
- The assessment should be uniform for all the years
- While developing the accounts for agriculture, we could not get data on the extent of contamination of waterways by fertilizers and pesticides which in turn leads to many negative health impacts.
- Data required for agricultural accounting is site-specific. It depends on local conditions, topography, crop management factors, etc. However, in line with our stated objectives, we used aggregate estimates available from various secondary sources. Site-specific estimates can be used at a more disaggregated level of accounts (such as the state and its districts) at a later stage.
- We did not consider the net emissions of green house gases from agricultural activities.
- In our replacement cost estimates for soil erosion we did not address the loss of organic carbon due to agriculture and instead modeled only N,P,K replacement.
- Our study does not consider other aspects of erosion, such as its effects on the soil's physical structure, moisture capacity, organic matter content, soil fauna and levels of many other nutrients. Moreover, the replenishment of soil nutrients by itself is insufficient to restore original soil productivity. The replacement of soil nutrients with fertilizers therefore oversupplies nutrients in available form and fails to replenish soil reserves of fixed nutrients. Furthermore, artificial fertilizers are subject to volatilization and leaching, which makes them highly inefficient at replacing soil nutrients; these losses should be taken into account in the calculation of replacement cost, though in practice they are ignored (Clark, 1996).

[19] Only the forest area that is prone to frequent fires is considered as affected by fire annually in this study.

[20] During the period 1947-72 the forests were classified as deciduous and broad-leaved forests. The area, volume of growing stock and volume of timber lost because of pests and diseases was available for that period. From this we computed the proportion of timber (volume of timber affected/total growing stock) affected annually and used the same proportion for the latest year.

- Even concerning the cost of sedimentation, we used an estimate of cost of sedimentation in reservoirs. Given that the rivers have a different hydrology and the sediment load is different, this estimate may be much lower.
- For pasture lands not much data is available. Detailed studies need to be undertaken.
- For developing water resource accounts not much data is available and whatever data is available is not sufficient to develop the accounts.
- For developing water resources accounts the following information is required:
- Information on the stock of surface and ground water (measures by volume of water) should be available uniformly for all the river basins.
- Extraction of water by different users domestic, industrial, livestock, hydropower and environmental needs by basin wise should be made available.
- The inflow in various basins and the outflow like evapotranspiration, transfer to seas and abstraction for different sub-basins uniformly for all the years.
- Price paid by various users of water
- The extent of pollution in various water ways, the volume of effluents and the expenditure incurred in cleaning up these effluents. The water quality data is available but more information is required on the exact conditions before measurement so that comparison can be made across the years. The data should be made available at least month-wise.
- Data can be uniformly collected using remote sensing techniques.

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